Teaching Scheme: B. Tech. (Mechanical Engineering) III Year

SEMESTER – V (Effective from AY 2022-2023)

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	Fluid Machines	ME301	4 – 0 – 2	4	100	-	50	150	05
2.	Design of Machine Components	ME303	3 – 1 – 2	3	100	25	50	175	05
3.	Machining Processes	ME305	3 – 1 – 2	3	100	25	50	175	05
4.	Institute Elective –1	ME3XX	3 – 0 – 0	3	100	-	--	100	03
5.	Core Elective – 1	ME3AA	3 – 0 – 0	3	100	-	-	100	03
6.	Professional Ethics, Economics and Business Management	HU308	3– 1 – 0	4	100	-	-	100	04
		Total	19 – 3 – 6	20	600	50	150	800	25

Institute Elective – 1 (ME3XX)

1. Plastic and Ceramics: ME361
2. Theory and Applications of Fluid Machinery*: ME363
3. Mechatronics: ME365
4. Control Systems: ME367
5. Engineering Estimation and Costing: ME369

*Except MED students

Core Elective – 1 (ME3AA)

1. Computational Fluid Dynamics: ME321
2. Maintenance & Safety Engineering:ME323
3. Powder Processing Techniques: ME325
4. Mechanics of Materials: ME327
5. Additive Manufacturing Processes:ME329

Fluid Machines

ME301

L	T	P	Credit
4	0	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Illustrate selection and application of various hydraulic and steam turbines
CO2	Explain the working principles of hydraulic pumps, and predict performance curves
CO3	Describe the working principles of steam power cycles
CO4	Explain working principles of steam nozzle
CO5	Explore various steam condenser, and cooling towers
CO6	Describe basic principles of pumps, fans, blowers and compressors

2. Syllabus

- **FUNDAMENTALS OF FLUID MACHINES (04 Hours)**

Classification of fluid machines, Impulse momentum principle, Basic equation of energy transfer in a fluid machines.

- **HYDRAULIC TURBINES (12 Hours)**

Classification, Pelton, Francis, Kaplan, Propeller turbines, Velocity triangles, power and efficiency calculations, draft tube, cavitation, Thoma's cavitation factors

- **HYDRAULIC PUMPS (12 Hours)**

Classification of different type of pump, principle of dynamic action & positive displacement type of pump, various parts of centrifugal pump & their function, theoretical analysis of energy transfer between fluid & rotor, losses, various efficiencies of the pump, performance characteristics, matching of pump & system characteristics, model analysis of centrifugal pump & specific speed, cavitation in pump & maximum suction lift.

- **STEAM POWER CYCLES (05 Hours)**

Simple steam power cycle, Rankine cycle, Rankine cycle efficiency, Comparison of Rankine & Carnot cycles. Reheat cycle, Regenerative cycle, Reheat -regenerative cycle, Cogeneration.

- **STEAM NOZZLES (05 Hours)**

Introduction, Types of Nozzles, Flow of steam through nozzles, Expansion of steam considering friction, Nozzle efficiency, Super-saturated flow through nozzle, Examples.

- **STEAM TURBINES (08 Hours)**

Introduction of steam and water turbine, Classification and general constructional features, Compounding of turbine. Impulse Turbine: Working principle, Forces on blades, Velocity diagrams, efficiency of multi stage turbine, Specific speed and performance characteristic curves for water turbine. Impulse Reaction Turbine: Working principle, Degree of reaction, Parson's reaction turbine, height of blade, Cavitation and performance characteristic curves for water turbine.

- **STEAM CONDENSOR AND COOLING TOWER (04 Hours)**

Introduction, Elements of steam condensing plant, Types of steam condensers, Thermodynamic analysis of condenser, Cooling towers.

- **FANS, BLOWERS AND COMPRESSORS (06 Hours)**

Construction and classification, governing equation, losses, performance curves, Positive displacement, Centrifugal and axial flow compressor, Components & their functions, velocity triangle, Performance, Slip factor, pre whirl, Choking, Surging & stalling, Degree of reaction.

(Total Lecture Hours: 56)

---

3. Practicals:

1. Study of Modern Steam Power Plant.
2. Estimation of power output & efficiency of a steam turbine.
3. Study of condenser and cooling tower.
4. Impact of jet on vanes.
5. Performance test on gear pump.
6. Performance test on jet pump.
7. Performance test on centrifugal pump.
8. Study and performance of water turbines.
9. Study of compressors.

4. Books Recommended:

1. S. Domkundwar, C.P. Kothandaraman and A.V. Domkundwar, A Course in Thermal Engineering, Dhanpat Rai and Co, 2018
2. J. Lal, Hydraulic Machines including Fluidics, Dhanpat Rai & Co, 2016.
3. S. K. Som, G. Biswas, S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill, 2017
4. P.K. Nag, Power Plant Engineering, Tata McGraw Hill Publications, 2017
5. S.M.Yahya, Turbines, Compressors and Fans, Tata McGraw Hill, 2017.

Design of Machine Components

ME303

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply design procedures to spur, helical, bevel and worm gear.
CO2	Design gear boxes for various industrial applications.
CO3	Design various types of mechanical brakes and clutches.
CO4	Design the journal and antifriction bearings.
CO5	Design belt drives, pulley, flywheel and power lifting devices
CO6	Apply the design concepts to miscelleneous machine components.

2. Syllabus

- **STATISTICAL CONSIDERATIONS IN MACHINE DESIGN (03 Hours)**

Probabilistic approach to design, statistical analysis of tolerances, reliability, statistical factor of safety, MTBF, reliability of systems in series and parallel.

- **DESIGN OF POWER TRANSMISSION ELEMENTS (17 Hours)**

Design of belt drives, selection of flat and V- belts, design of pulleys and flywheels, design of gear drives – spur, helical, bevel and worm gear drives, design of single and multistage speed reducers. Design of gear boxes: Types of gear boxes, design of machine tool gear boxes using preferred numbers.

- **DESIGN OF CLUTCHES AND BRAKES (05 Hours)**

Types of clutches, design of single and multiple plate clutches, cone and centrifugal clutch, design of block brake, pivoted shoe brake, long shoe brake, internal shoe brake, simple and differential band brake.

- **DESIGN OF BEARINGS (08 Hours)**

Design of hydrodynamic journal bearings, classification, material selection, Sommerfeld number and use of charts for the estimation of minimum film thickness, temperature rise, flow quantity etc. design of pressure fed and self-contained bearings, rolling contact bearings, classification, selection factors affecting bearing life, bearing assembly and lubrication.

- **MISCELLANEOUS MACHINE ELEMENTS (05 Hours)**

Selection of steel wire rope for hoists and cranes, crane hooks, design of pressure vessels: thin and thick cylinder, stresses and types of failures.

- **DESIGN OF I.C. ENGINE COMPONENTS (04 Hours)**

Piston, cylinder and connecting rod.

(Total Lecture Hours: 42)

3. Practicals:

1. Drawing of involute gear profile.
2. Design of spur gear.
3. Design of helical gear.
4. Design of journal bearing.
5. Design of two stage speed reducer gear box with its kinematic arrangement.
6. Design and drawing of automobile clutch of any of the following:
    a. Plate clutch,
    b. Centrifugal clutch,
    c. Multi-plate clutch.
7. Design and drawing of the any of the brake from following:
    a. External expanding brake,
    b. Internal expanding brake,
    c. Differential band brake.
8. Design and drawing of hook block.
9. Selection and mounting of rolling element bearing.
10. Design of bevel gear.

4. Books Recommended:

1. R. G. Budynas and K. Nisbett, Shigley's Mechanical Engineering Design, 11th Edition, McGraw Hill, 2020.
2. V. B. Bhandari, Design of Machine Elements, 4th Edition, Tata McGraw Hill, 2016.
3. R. L. Norton, Machine Design, 5th Edition, Pearson Education India Ltd., 2014.
4. M. F. Spotts, Design of Machine Elements, Pearson Education India Ltd., 2004.
5. R. C. Juvinall and K. M. Marshek, Fundamentals of Machine Component Design, 6th Edition, Wiley, 2017.

Machining Processes

ME305

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe and identify machining processes, tool material and geometry and mechanism
CO2	Select, describe and perform turning and shaping operation using given cutting tools on identified machine tool
CO3	Select, describe and perform drilling and milling operation using given cutting tools on identified machine tool
CO4	Calculate machining time and allied characteristics for identified machining process
CO5	Select, describe and perform finishing of parts using standard tools
CO6	Calculate features and fabricate different types of gears using identified process

2. Syllabus

- **MECHANICS OF MACHINING (10 Hours)**

Mechanism of chip formation, types of chips, chip breakers, Marchant circle diagram, cutting forces and power, tool wear and tool life; machinability; economics of machining; cutting tool materials; types of tools.

- **CONVENTIONAL MACHINING PROCESSES (16 Hours)**

Introduction to Turning, shaping, planning, milling, drilling, broaching processes; types of machines and operations; different mechanisms on the machine; tool and work holding devices; special attachments; capstan and turret machine; automats; machining time calculations.

- **FINISHING PROCESSES (06 Hours)**

Introduction to grinding, types of machines and operations, dressing and trueing, glazing, designating system, selection of grinding wheel, lapping, honing, super finishing processes.

- **THREAD AND GEAR MANUFACTURING PROCESSES (05 Hours)**

Thread manufacturing by thread milling and thread grinding. Gear milling, hobbing and finishing.

- **INTRODUCTION TO UNCONVENTIONAL MACHINING PROCESSES (05 Hours)**

(Total Lecture Hours: 42 Hours)

3. Practicals:

1. Machining Practices on lathe for step turning, taper turning, grooving, thread cutting operations.
2. Machining practices on shaping and drilling machine.
3. Machining practices on milling machine to cut spur or helical gear.

4. Calculation of shear plane angle under different machining conditions.
5. Measurement of chip tool interface temperature under different machining conditions.
6. Grinding Practice of single point cutting tool and measure tool angles.
7. Demonstration of Capstan lathe.
8. Demonstration of EDM process.

4. Books Recommended:

1. H.M.T., Production Technology, Tata McGraw-Hill Education, 2004.
2. S. K. Hajra Choudhury, Element of Workshop Technology, Vol. 2, 14th Edition, Media Promoters and publishers Pvt., 2010.
3. V. K. Jain, Advanced machining processes. Allied publishers, 2009.
4. A. B. Chattopadhyay, Machining and Machine Tools, 2nd Edition, John Wiley & Sons, 2017.
5. S. Kalpakjian, S. R. Schmid, Manufacturing Engineering and Technology, 7th Edition, Pearson, 2018

Plastics and Ceramics

ME361

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe fundamentals of plastic and ceramic materials.
CO2	Identify the importance of manufacturing processes used to manufacture plastic and ceramic products.
CO3	Establish design guidelines and testing associated with production of plastic products.
CO4	Analyze plastic recycling and waste management practices.
CO5	Distinguish sintering mechanisms considered for ceramic materials.
CO6	Compile properties of various plastic and ceramic materials and its comparison with other classes of materials.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

Classification of materials, history of plastic materials, comparison of plastics with other engineering materials. Classification of plastics, thermoplastic, thermoset plastics, elastomers and polymers. Polymer structures, polymerization, properties of polymers, additive methods to modify polymers. National and International organizations dealing with plastic materials.

- **PROCESSING OF PLASTICS** **(10 Hours)**

Injection molding, extrusion molding, blow molding, rotational molding, vacuum molding, thermoforming, compression molding, resin transfer molding, calendaring process, etc. Secondary processes for plastics i.e. machining, joining, painting, etc. Defects during processing of plastic products.

- **DESIGN AND TESTING OF PLASTICS PRODUCTS** **(06 Hours)**

Commodity plastics, engineering plastics, speciality plastics. Design guidelines for products, design guidelines for various processes, importance of mold making. Concept of testing, specification and standards. Overview of various tests, significance of important thermal and mechanical properties of plastic materials.

- **PLASTICS RECYCLING AND WASTE MANAGEMENT** **(05 Hours)**

Applicability and statistics of plastics in various sectors. Issues and challenges with plastics. Impact of plastics on environment and its remedies. Utility of plastics wastes, waste management practices, plastic recycling processes. Case studies for recycling and waste management.

- **CERAMIC MATERIALS** **(06 Hours)**

Introduction to ceramic materials, history of ceramic materials, comparison of ceramics with other engineering materials. National and International organizations dealing with ceramics. Atomic bonding and crystal structures in ceramics, traditional and engineering ceramics, classification of ceramics based on properties and applications. Factors affecting properties of ceramics.

- **PROCESSING OF CERAMICS** **(09 Hours)**

Material selection. Powder making processes. Processing of ceramic materials i.e. slip casting process, ceramic injection molding, tape casting process, etc. Significance of sintering in ceramics, sintering mechanisms, stages during sintering, Importance of phase equilibrium diagrams, Gibbs phase rule, silica phase diagram, phase diagrams for other ceramics.

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. T. L. Szabo, Plastics – Inside Out, 3rd Edition, Elsevier Butterworth-Heinemann, 2005.
2. R. J. Crawford and P. J. Martin, Plastics Engineering, 4th Edition, Elsevier Butterworth-Heinemann, 2020.
3. J. R. Fried, Polymer Science and Technology, 3rd Edition, Prentice Hall, 2014.
4. M.W. Barsoum, Fundamentals of Ceramics, 2nd Edition, CRC Press, 2019.
5. M. N. Rahaman, Ceramic Processing and Sintering, 2nd Edition, CRC Press, 2003.

Theory and Applications of Fluid Machinery

ME363

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Classify fluid machines and explain the concept and performance parameters of fluid machines
CO2	Explain the construction and working of fan and blowers and select the appropriate machines for different applications
CO3	Identify types of compressors, calculate various performance parameters and analyze the performance characteristics
CO4	Compare the working of different types of pumps and evaluate the performance of pumps, Select the appropriate pump for suitable application
CO5	Classify hydraulic turbines, investigate velocity triangles and analyze the function of various components and cavitation phenomena
CO6	Identify measuring and performance parameters, Calculate the performance parameters, Evaluate the performance of fluid machines

2. Syllabus

- **INTRODUCTION TO FLUID MACHINES** **(08 Hours)**

Classification of fluid machines: Positive displacement type and dynamic type machinery; Impulse type and reaction type machinery; reciprocating, radial, mixed and axial flow machines, Basic fluid mechanics of fluid machines, The torque momentum and head momentum equations; one dimensional theory and its limitations, specific work and its representation on T-s and h-s diagrams; losses and efficiencies; energy transfer in fluid machines

- **FANS AND BLOWER** **(06 Hours)**

Classification and Construction; performance analysis: Power required, pressure rise, efficiency calculations; characteristic curves and selection, fan drives and fan noise. Applications in boilers, cooling towers, and other industrial applications

- **COMPRESSORS** **(06 Hours)**

Centrifugal Compressors: Construction and working, Types, performance: work done and pressure rise; Slip; Compressibility effects; Surging and choking of compressors; Compressor characteristics and applications.

Axial Flow Compressors: Working, performance parameters: Stage pressure rise; polytrophic efficiency, degree of reaction; Surging and stalling of compressors; Compressor performance and characteristic curves, Off design performance and applications.

- **PUMPS** **(08 Hours)**

Main elements and their functions, Various types and classification, Pressure changes in a pump - suction, delivery and manometric heads, head-capacity relationships, losses, pump output and efficiency, Minimum starting speed, Priming and priming devices, Multistage pumps - series and parallel arrangement; submersible pumps, Axial and mixed flow pumps: Construction and operation, NPSH and cavitation in pump.

- **HYDRAULIC TURBINES (08 Hours)**

Classification, Pelton, Francis, Kaplan, Propeller turbines, Velocity triangles, power and efficiency calculations, draft tube, cavitation, Thoma's cavitation factors

- **PERFORMANCE CHARACTERISTICS OF FLUID MACHINES (06 Hours)**

Pressure, temperature, velocity, head, capacity, and power measurement, model testing, similarity laws, unit quantities, specific quantities, main operating and constant efficiency curve.

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. S. R. Gorla Rama, A.A. Khan, Turbomachinery Design and Theory, CRC Press- Taylor and Francis Group, 2011.
2. S. Ramachandran, R. Devaraj, Y.V.S. Karthick, Fluid Machinery, Airwalk Publications, 2017.
3. S.M.Yahya, Turbines, Compressors and Fans, Tata McGraw Hill, 2017.
4. A.T. Sayers, Hydraulic and compressible flow turbomachines. McGraw-Hill Publishing Co., 1990.
5. V. Kadambi and M. Prasad, An introduction to energy conversion, New Age International Private Limited, 2011.

Mechatronics

ME365

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basic elements of mechatronics system.
CO2	Analyze the functioning of sensors, transducers and actuators.
CO3	Analyze and evaluate the electronic elements such as digital circuits, AD convertors, etc.
CO4	Explain the basics of PLC programming
CO5	Develop a mechatronic system using the gained knowledge.
CO6	Apply the programming logic to electronic sytem design

2. Syllabus

- **INTRODUCTION TO MECHATRONICS** **(01 Hour)**

- **MECHATRONIC SYSTEM ELEMENTS** **(04 Hours)**

Measurement system, Control system, Microprocessor based controllers & its applications, other applications with mechatronic approach, Building blocks of mechatronic system.

- **SENSORS & TRANSDUCERS** **(09 Hours)**

Classification, Performance terminologies, Displacement, Position & proximity sensors, Photo detectors, Optical encoders, Pneumatic sensor, Hall effect sensor, Velocity & motion sensors: Incremental encoder, Tachogenerator, Piezo electric sensors, Tactile sensors, Flow & temperature sensors: Ultrasonic sensors, Light sensors, Selection of sensors, Interference & noise in measurement.

- **ACTUATION SYSTEMS** **(10 Hours)**

Pneumatic & hydraulic actuation systems: System configuration, Control System & its elements, Linear actuators, Rotary actuators. Mechanical actuation: System types & its configuration, fixed ratio type, Invariant motion profile type, variator etc. Electrical actuation system types & configurations, Mechanical switches, Solid state switches, Solenoids.

- **DIGITAL CIRCUITS** **(08 Hours)**

Boolean algebra combinational circuits. (Adders, Subtractors, encoders, decoders, multiplexers, de – multiplexers, memory units: RAM, ROM, EPROM etc.), Sequential circuits (Latches, Flip-flops, Counters, Registers).

- **ANALOG SIGNAL PROCESSING** **(06 Hours)**

Amplifiers, Operational amplifiers, Ideal model for operational amplification, Inverting amplifier, Non-inverting amplifier, Summer, Difference amplifier, Instrumentation amplifier, Integrator, Differentiator, Sample & hold circuit, Comparator, Basics of filters, Types of filters, Introduction to A/D and D/A converters.

- **ELECTRONIC SYSTEM DESIGN** **(04 Hours)**

Introduction to MPU & MCU, Assembly programming, Interfacing, Introduction to PLC & basics of PLC programming.

(Total Lecture Hours: 42)

3. Books Recommended:

1. D. Shetty, A. R. Kolk, Mechatronic System Design, 2nd Edition, PWS Publicity Boston, 2010.
2. W. Bolton, Mechatronics, 4th Edition, Pearson Education (India), 2011.
3. HMT Ltd., Mechatronics, 1st Edition, Tata McGraw Hill Publication, 2002
4. D. Necsulescu, Mechatronics, Pearson Education (Singapore), 2002.
5. M. Mano, Digital Logic & Computer Design, 4th Edition, Pearson, 2016.

Control Systems

ME367

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the theory and applications of control systems and draw block diagrams techniques, signal flow graphs of linear systems and their controlling actions.
CO2	Apply the knowledge of control systems components for hydraulic and pneumatic applications.
CO3	Apply the concept of standard test signals and transient response of first and second order systems, evaluate the sources of static and dynamic error constant.
CO4	Analyze the stability criteria for frequency response.
CO5	Analyze the behavior of closed loop systems using tools such as root locus, Routh Hurwitz, Bode, Nyquist, and Matlab.
CO6	Describe the control system design, Fuzzy logic, fuzzy set and fuzzy control, PLC

2. Syllabus

- **BASIC COMPONENTS OF CONTROL SYSTEM** **(08 Hours)**
  Open loop and Closed loop system – Automatic Control System. Mathematical Modeling, Analogous Models – Mathematical modelling of fluid system and thermal systems – Transfer Function – Block diagram reduction Techniques, signal flow graphs.

- **REPRESENTATION OF PHYSICAL SYSTEM** **(06 Hours)**
  Linear approximation of nonlinear System – position Control system – Stepper motor – Hydraulic systems – pneumatic systems – Inertial navigation system – Applications.

- **MODES OF CONTROLS** **(06 Hours)**
  Proportional, Integral, Derivative – proportional plus integral – proportional plus Derivative– proportional Plus integral plus derivative controls – examples from Mechanical system.

- **TIME DOMAIN ANALYSIS OF CONTROL SYSTEMS** **(08 Hours)**
  Classifications of time response, systems time response, analysis of steady state error, Standard test signals and transient response of first and second order systems**.** Sources of errors, static and dynamic error constants, Routh Hurwitz Stability Criteria.

- **FREQUENCY RESPONSE** **(06 Hours)**
  Bode Plot – Polar Plot. Stability Analysis – Relative stability

- **DESIGN PRINCIPLES** **(08 Hours)**
  An outline of Control System Design - Control of the A/F ratio in an Automotive Engine – Control of Read/Write Head Assembly of a Hard Disk. Introduction to Fuzzy logic – Fuzzy set – Fuzzy Control – PLC

(Total Lecture Hours: 42)

3. Books Recommended:

1. G. F. Franklin, Feedback control of Dynamic Systems, 7th Edition, Pearson Education Asia, 2014
2. I. J. Nagrath and M.Gopal, Control System Engineering, 6th Edition, New Age International Pvt Ltd, 2018
3. K. Ogata, Modern Control Engineering, 5th Edition, Pearson Education India, 2015.
4. J. W. Webb & R. A. Reis, Programmable Logic Controllers: Principles and Applications, 5th Ed, PHI Learning, New Delhi, 2002
5. S. Gosh, Theory & application of control systems, Person Education, 2010

Engineering Estimation and Costing

ME369

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Analyze the concept of estimation for various industrial applications..
CO2	Analyze the concept of cost accounting and control.
CO3	Develop knowledge of time value of money, cash flows in organizations and learn the concept of taxation
CO4	Apply engineering economics and analyze the breakeven point for single and multiple product production cases.
CO5	Demonstrate the effects of depreciation and replacement policy in engineering economic
CO6	Explain the concepts of financial management and accounting.

2. Syllabus

- **ESTIMATING** **(06 Hours)**

  Objectives of estimating –constituents of estimate, mechanical estimating – costing and cost estimation, functions of estimation organization and prerequisites of estimation, estimating such as design and drafting period, time & motion studies, time allowances etc., estimation of material, labour cost, production estimate sheet, advantages & elements of costing, classification of cost elements.

- **COST ACCOUNTING AND CONTROL** (**06 Hours**)

  Cost accounting, elements of cost, factors affecting selling price, fixed cost, variable cost, computation of actual cost, nature of cost, type of cost and cost control

- **ENGINEERING ECONOMICS & BREAK EVEN ANALYSIS** (**10 Hours**)

  Introduction, time value of money, cash flows, taxation concept, tools for engineering economics, models, operation research, value engineering, make and buy decisions, economic batch size, locational economics, benefits cost ratio, break even analysis, analytical and graphical methods, single products and multiple product cases

- **DEPRECIATION AND REPLACEMENT ANALYSIS** **(10 Hours)**

  Concepts, classification, methods of depreciation, comparison of different depreciation method, selection of depreciation methods, obsolescence, reasons for replacement of equipment, development of systematic replacement programme/policy, replacement models, sudden failure, failure tress.

- **FINANCIAL MANAGEMENT AND ACCOUNTING** **(10 Hours)**

  Definitions and functions of financial management, sources of funds, capitals and its classification, capitalization, sourcing of funds, shares, debentures, trade credits, pubic deposits, banking, foreign exchange and trade, nature of accounting, accounting terminology and types, rules for debit and credit, financial ratios, budget and budgetary control

(Total Lecture Hours: 42)

3. Books recommended:

1. J. Heizer, B. Render, C. Munson, and A. Sachan, Operations Management, 12th Edition, Pearson Education, 2017.
2. M. Mahajan, Industrial Engineering and Production Management, 1st Edition, DhanpatRai & Co. (P) Limited, 2015.
3. B.P. Sinha, Mechanical Estimating and Costing, 1st Edition, Tata McGraw Hill Publishing Co. Ltd., 1995.
4. T.R. Banga and S. C. Sharma, Industrial Organization and Engineering Economics, 24th Edition, Khanna Publishers, 2013.
5. S. K. Sharma and S. Sharma, Industrial Engineering &Organization management, Reprint Edition, S K Kataria and Sons, 2013.

Computational Fluid Dynamics

ME321

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Develop mathematical model for fluid flow and associated transport processes
CO2	Classify various discretization methods and errors associated with numerical solution
CO3	Discretize the fundamental equations of flow and other transport processes using finite
CO4	Apply finite volume method for numerical modeling of fluid flow
CO5	Solve two-dimensional incompressible viscous flow problems using stream functionvorticity formulation
CO6	Solve Navier-Stokes equations for incompressible flows using semi-explicit and semiimplicit algorithms

2. Syllabus

- **GOVERNING EQUATIONS FOR FLUID FLOW AND HEAT TRANSFER (06 Hours)**
  Conservation of Mass, Newton's Second Law of Motion, Expanded Forms of Navier stokes equations, Conservation of Energy Principle, Special Forms of the Navier Stokes Equations, Classification of Second order Partial Differential Equations, Initial and Boundary Conditions, Governing Equations in Generalized Coordinates.

- **FINITE DIFFERENCE, DISCRETIZATISON, CONSISTENCY, STABILITY (06 Hours)**
  Elementary Finite Difference Quotients, Basic Aspects of Finite Difference Equations, Errors and Stability Analysis, Some Nontrivial Problems with Discretized Equations

- **FINITE VOLUME METHOD FOR FLUID FLOW MODELING (12 hours)**
  Integral Approach, Discretization of Unsteady, Diffusion, Advection and Source Terms, Advection Schemes: Central Difference Scheme, First Order Upwind Scheme, Second Order Upwind Scheme, QUICK scheme and Other Higher Order Schemes, Finite Volume Solution of Unsteady Advection, Diffusion Problems with Source Term.

- **SOLUTION OF VISCOUS INCOMPRESSIBLE FLOWS BY STREAM FUNCTION – VORTICITY FORMULATION (08 Hours)**
  Two Dimensional Incompressible Viscous Flow, Incorporation of Upwind Scheme, Estimation of Discretization Error, Application to Curvilinear Geometries, Derivation of Surface Pressure and Drag.

- **SOLUTION OF NAVIER -STOKES EQUATIONS FOR INCOMPRESSIBLE FLOWS USING SEMI-EXPLICIT AND SEMI-IMPLICIT ALGORITHMS (10 Hours)**
  Collocated and Staggered Grid, Solution of Unsteady Navier-Stokes Equations using Semi-explicit method, for Collocated and Staggered grid, Momentum Interpolation, SIMPLE Algorithm, Formulation of Coupled Flow with Heat Transfer and Other Scalar Transport.

(Total Lecture Hours: 42)

3. Books Recommended:

1. D.A. Anderson, Tannehill J.C., Pletcher R.H., Computational Fluid Mechanics and Heat Transfer, CRC Press, 2012.
2. K. Murlidhar, T. Sunderarajan, Computational Fluid Flow and Heat Transfer, Narosa Publisher, 2013
3. J.D. Anderson, Computational Fluid Dynamics, McGraw Hill, 2017.
4. S.V. Patanankar, Numerical Heat Transfer and Flow, Hemispehre Publ. Corporation, 2017.
5. H. K. Versteag, and W. Malalsekara, An Introduction to Computational Fluid Dynamics, Pearson, 2008

Maintenance and Safety Engineering

ME323

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the principles, functions and practices adapted in industry for the successful management of maintenance activities.
CO2	Apply the knowledge of Predictive maintenance and conditioning monitoring concepts for industrial applications.
CO3	Use vibration and noise as tools to predict failures for preventive maintenance and help optimize the lifespan of industrial assets
CO4	Apply the concept of failure pattern, system reliability: Series, Parallel and Mixed
CO5	Explain the safety engineering aspects in industry.
CO6	Design and develop safety codes and standards for machines and com

2. Syllabus

- **OBJECTIVE OF MAINTENANCE** **(09 Hours)**
  Types of maintenance – Breakdown, preventive and predictive maintenance - Repair cycle - Repair Complexity, Lubrication and Lubricants. Maintenance of Mechanical transmission systems and process plants.

- **PREDECTIVE MAINTENANCE** **(09 Hours)**
  Vibration and noise as maintenance tool - wear debris analysis - Condition monitoring concepts applied to industries - Total Productive Maintenance (TPM) - Economics of Maintenance- Computer aided maintenance

- **RELIABILITY** **(09 Hours)**
  Definition, concept of reliability based design, failure rate, MTTF, MTBF, failure pattern, system reliability: Series, Parallel and Mixed configurations - Availability and Maintainability concepts- Applications.

- **SAFETY AND PRODUCTIVITY** **(08 Hours)**
  Causes of accidents in industries – accident reporting and investigation - measuring safety performance - Safety organizations and functions - Factories act and rules.

- **SAFETY CODES AND STANDARDS** **(07 Hours)**
  General Safety considerations in Material Handling equipment - Machine Shop machineries-pressure vessels and pressurized pipelines – welding equipment – operation and inspection of extinguishers – prevention and spread of fire–emergency exit facilities.

(Total Lecture Hours: 42)

3. Books Recommended:

1. P. Gopalakrishnan, Maintenance and Spare Parts Management, 2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2013
2. L. S. Srinath, Reliability Engineering, Affiliated East West press, 2005
3. Rolland P. Blake, Industrial Safety, 3rd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
4. R. C. Mishra and K. Pathak, Maintenance Engineering and Management, 2nd Edition, Prentice Hall of India Pvt.Ltd.,New Delhi, 2012.
5. E. Balagurusamy, Reliability Engineering, McGraw Hill Education, 2017.

Powder Processing Techniques

ME325

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the importance of powder processing route of manufacturing process, and compare powder metallurgy products with cast & wrought products.
CO2	Compare different techniques of production of ceramic, metal, nano-powders and microencapsulated powders.
CO3	Perform testing and characterization of ceramic and metal powders.
CO4	Describe different methods of conditioning of powders and analyze various techniques of compactions of powder products.
CO5	Describe mechanism of sintering of green powder compacts and secondary & finishing
CO6	Explain detailed procedure of manufacturing of selected products by powder processing.

1. Syllabus:

- **INTRODUCTION (06 Hours)**

History, Basic terms related to powder processing, principle and outline of powder processing techniques, advantages and limitations of powder processing, General characteristics of ceramic and metal powders. Comparison of powder processed parts with cast and wrought products, Design considerations in powder metallurgy.

- **PRODUCTION OF POWDERS (06 Hours)**

Atomization, variants of atomization, Chemical reduction, Carbonyls, Electrolytic deposition, Mechanical pulverization methods - crushing, milling etc.; vapour condensation, precipitation from chemical solution, high temperature extractive metallurgy processes, production of nano powders, Microencapsulated powders.

- **TESTING & CHARACTERIZATION OF POWDERS (06 Hours)**

Physical characterization related to powder particles - shapes, size, mesh number, size distribution, surface area, porosity; flow rate, tap density, apparent density, true density, compressibility and friction; chemical characterization related to chemical compositions, phase composition and surface characterization.

- **POWDER CONDITIONING AND HEAT TREATMENT (03 Hours)**

Alloying, sintering aids, lubricants, plasticizers and binders, mixing and blending, granulation; Equipment for powder conditioning, Heat treatments of powders.

- **COMPACTION OF POWDER PRODUCTS (07 Hours)**

Conventional die pressing, pressure distribution during conventional die pressing, cold iso-static pressing, powder rolling, powder extrusion, injection moulding, hot iso-static pressing, spray deposition (Osprey process), pressureless compaction, compaction using ceramic molds.

- **SINTERING & SECONDARY OPERATIONS (10 Hours)**

Defects and defect chemistry; Solid state sintering, atomic mechanisms, coarsening, densification, sintering kinetics: sintering stages, coarsening and grain growth growth kinetics; Liquid phase sintering: introduction, the different stages, controlling kinetics and thermodynamic factors; Sintering furnaces and their classifications, batch furnace, continuous furnaces, sintering atmosphere, vacuum sintering. Finishing, machining, infiltration, Repressing, Resizing, Impregnation.

- **SELECTED POWDER PRODUCTS (04 Hours)**

Sintered carbides and carbide tools; Cermets; Dispersion strengthened materials; Automotive-engine bearing cap, Electrical contact materials; Self-lubricating bearings & gears, Filters, Friction materials.

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. R. M. German, Powder Metallurgy and Particulate Materials Processing, MPIF, 2005.
2. K. Hingashitani, H. Makino, S. Matsusaka, Powder Technology Handbook, CRC Press, 2019.
3. A. Upadhyaya, G. S. Upadhyaya, Powder Metallurgy - Science, Technology & Materials, Universities Press, Taylor & Fracis, 2018.
4. P. C. Angelo, R. Subramanian, Powder metallurgy - Science, Technology and Applications, PHI Learning Pvt. Ltd., 2008.
5. B. K. Datta, Powder Metallurgy: An Advanced Technique of Processing Engineering Materials, 2014.

Mechanics of Materials

ME327

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the mechanical properties of materials
CO2	Illustrate the theoretical basis about the stress, strain and elastic modulus in components.
CO3	Analyze members under uni-axial and axi-symmetric loads.
CO4	Analyze members under torsional loads.
CO5	Analyze deflection, moment area, unit-load, Strain energy for members under flexural loads
CO6	Analyze elastic stability of columns

2. Syllabus

- **ANALYSIS OF STRESS AND STRAIN (10 Hours)**

Introduction: Stress and strain: stress at a point, Cauchy stress tensor, analysis of deformation and definition of strain component, principal stresses and strain, stress and strain invariant, Mohr's circle representation. Hooke's law and its application to isotropic materials, elastic constants and their relationships, plane stress and plain strain conditions.

- **MECHANICAL PROPERTIES (03 Hours)**

Uniaxial tension test to determine yield and ultimate strength of materials, stress-strain diagram, proof stress, ductile and brittle materials, hardness and impact strength, conditions affecting mechanical behaviour of engineering materials.

- **MEMBERS IN UNI-AXIAL STATE OF STRESS (04 Hours)**

Uniform cross-section and tapered bars subjected to uniaxial tension and compression, composite bars and statically indeterminate bars, thermal stresses; Introduction to plasticity; Strain energy under axial loading.

- **MEMBERS SUBJECTED TO AXI-SYMMETRIC LOADS (03 Hours)**

Stresses and strains in thin cylindrical shells and spheres under internal pressure, stresses in thin rotating rings.

- **MEMBERS SUBJECTED TO TORSIONAL LOADS (04 Hours)**

Torsion of solid and hollow circular shafts, stepped and composting shafts, Shafts subjected to combined bending, torsion and axial thrust, Strain energy in torsion.

- **MEMBERS SUBJECTED TO FLEXURAL LOADS (13 Hours)**

Statically determinate beams, support reactions, relationship between load, shear force and bending moment, shear force and bending moment diagrams; theory of flexure for initially straight beams, distribution of bending stresses across the beam cross-section, principal stresses in beams; equation of elastic curve for the loaded beam, relationship between bending moment, slope and deflection; calculation of deflection by integration, moment area and unit-load methods, Strain energy in flexure.

- **ELASTIC STABILITY OF COLUMNS (05 Hours)**

Euler's theory of initially straight columns, critical loads for different end condition of columns, eccentric loading, columns with small initial curvature, empirical formulae, Short struts subjected to eccentric loads. Energy methods: principle of virtual work, minimum potential energy, Introduction to theory of photo-elasticity.

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. F. P. Beer, E. R. Johnston, Jr., J. T. Dewolf and D. E. Mazureu, Mechanics of Materials, 5th Edition, McGraw Hill, 2009.
2. S. P. Timoshenko and D. H. Young, Elements of Strength of Materials, 5th Edition, East-West Press Pvt. Ltd., 2009.
3. S. Ramamurtham, Strength of Materials, Dhanpat Rai Publications, 2005.
4. E. P. Popov, Engineering Mechanics of Solids, Prentice-Hall, 1999.
5. L. S. Srinath, Advanced Mechanics of Solids, 3rd Edition, Tata McGraw Hill, 2009.

Additive Manufacturing Processes

ME329

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Compare and distinguish various additive manufacturing processes.
CO2	Explain the process chain for selected additive manufacturing process.
CO3	Perform and analyze various materials using stereo lithography, laser sintering and electron beam melting.
CO4	Compare and recommend suitable additive manufacturing process for a given material
CO5	Identify defects in model and reframe in standard format.
CO6	Integrate design concepts with CAD or reverse engineering for geometry preparation for additive manufacturing of part.

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

Definition, classification, stages of generic additive manufacturing process, benefits, applications, process selection, evaluation, benchmarking, future growth and opportunities

- **LIQUID BASED PROCESSES** **(08 Hours)**

Photo polymerization, principle and working of stereo lithography apparatus, scanning techniques, curing processes, typical materials and applications.

- **POWDER BASED PROCESSES** **(08 Hours)**

Powder fusion mechanism, powder handling and recycling, Principle and working of Selective Laser Sintering, Laser Engineering Net Shaping process, Electron Beam Melting, process parameters, typical materials and applications.

- **SOLID BASED PROCESSES** **(08 Hours)**

Basic principle and working of fused deposition modelling process, liquification, solidification and bonding, bio extrusion, Laminated Object Manufacturing process, Multi jet process, typical materials and applications

- **SOFTWARE ISSUES IN ADDITIVE MANUFACTURING** **(06 Hours)**

Preparation of CAD models and STL files, STL file problems and repair, slicing, newly proposed formats, standards, softwares to assist additive manufacturing, role of reverse engineering.

- **DESIGN FOR ADDITIVE MANUFACTURING** **(06 Hours)**

Core concepts and objectives, unique capabilities of Additive Manufacturing, exploring design freedom, design tools.

(Total Lecture Hours: 42)

3. Books Recommended:

1. I. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies, Springer Publisher, 2010.
2. C. K. Chua, K. F. Leong, C. S. Lim, Rapid Prototyping – Principles and Applications, World Scientific, 3rd Edition, 2010.
3. R. Noorani, 3D printing technology, applications and selection, CRC Press, 2017.
4. M. W. M. Cunico, 3D Printers and Additive Manufacturing: the rise of the Industry 4.0, Concept 3D, 2019
5. A. Bandyopadhyay and S. Bose, Additive Manufacturing, CRC Press, 2015

Professional Ethics, Economics and Business Management

HU308

L	T	P	Credit
3	1	0	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Identify application of ethics in society and development of understanding regarding Professional ethical issues related to Mechanical engineering
CO2	Develop managerial skills to become future engineering managers
CO3	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO4	Build knowledge about modern management concepts (ERP, SCM, e-CRM, etc.)
CO5	Develop experiential learning through Management games, Case study discussion, Group discussion etc.
CO6	Apply knowledge of Economics and Business management aspects in Mechanical engineering.

2. Syllabus:

- **PROFESSIONAL ETHICS** **(14 Hours)**

  Introduction, Approaches to Ethics, Meaning of Ethics, Major attributes of Ethics, Business Ethics, Factors influencing Ethics, Importance of Ethics, Ethics in Management, Organizational Ethics, Ethical aspects in Marketing, Mass communication and Ethics - Television, Whistle blowing, Education – Ethics and New Professional, Intellectual Properties and Ethics, Introduction to Professional Ethics, Engineering Ethics, Ethical issues related to Mechanical Engineering

- **ECONOMICS** **(08 Hours)**

  Introduction To Economics, Micro & Macro Economics, Applications & Scopes Of Economics, Demand Analysis, Demand Forecasting, Factors Of Production, Types Of Cost, Market Structures, Break Even Analysis

- **MANAGEMENT** **(12 Hours)**

  Introduction to Management, Features Of Management, Nature Of Management, Development of Management Thoughts – Scientific Management By Taylor & Contribution of Henry Fayol, Coordination & Functions Of Management, Centralization & Decentralization, Decision Making; Fundamentals of Planning; Objectives & MBO; Types of Business Organizations: Private Sector, Public Sector & Joint Sector; Organizational Behavior: Theories of Motivation, Individual & Group Behavior, Perception, Value, Attitude, Leadership

- **FUNCTIONAL MANAGEMENT** **(18 Hours)**

  Marketing Management: Core Concepts Of Marketing, Marketing Mix (4p), Segmentation

– Targeting – Positioning, Marketing Research, Marketing Information System, Concept of International Marketing, Difference Between Domestic Marketing & International Marketing;

Operations Management: Introduction to Operations Management, Types of Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management; Personnel Management: Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Collective Bargaining; Financial Management: Goal of Financial Management, Key Activities In Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance

- **MODERN MANAGEMENT ASPECTS** **(04 Hours)**

  Introduction to ERP, e – CRM, SCM, RE – Engineering, WTO, IPR Etc.

(**Total Lecture Hours: 56)**

3. Books Recommended:

1. V. Balachandran and Chandrasekaran, Corporate Governance, Ethics and Social Responsibility, PHI, 2nd Edition, 2011
2. L.M. Prasad, Principles & Practice of Management, Sultan Chand & Sons, 8th Edition,2015
3. T. R. Banga & S.C. Sharma, Industrial Organization & Engineering Economics, Khanna Publishers, 25th Edition, 2015
4. Everett E. Adam, Ronald J. Ebert, Production and Operations Management, Prentice Hall of India, 5th edition, 2012
5. P. Kotler P., K. L. Keller, A. Koshi & M. Jha, Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014

SEMESTER – VI (Effective from AY 2022-2023)

Sr. No.	Subject	Code	Scheme	Exam Scheme				Total	Credit
				Theory		Tuto.	Pract.		
				Hrs.	Marks	Marks	Marks		
1.	Tribology and Mechanical Vibrations	ME302	3 – 1 – 2	3	100	25	50	175	05
2.	Production Technology	ME304	3– 0 – 2	3	100	-	50	150	04
3.	Applied Thermal Engineering	ME306	4 – 0 – 2	4	100	-	50	150	05
4.	Institute Elective – 2	ME3YY	3 – 0 – 0	3	100	-	-	100	03
5.	Core Elective - 2	ME3BB	3 – 0 – 0	3	100	-	-	100	03
6.	Core Elective - 3	ME3CC	3 – 0 – 0	3	100	-	-	100	03
7.	Project Preliminary	ME308	0 – 0 – 4	0	-	-	100	100	02
		Total	19 –1–10	19	600	25	250	875	25

Institute Elective – 2 (ME3YY)

1. Corrosion Engineering: ME362
2. Energy Efficiencies in Industrial Utilities[#]: ME364
3. Product Design and Development: ME366
4. Lubrication Technology: ME368
5. Plant Layout and Material Handling: ME372
6. Risk, Reliability and Life Testing: ME374
7. Materials Management: ME376

Except ECED and CoED students

Core Elective – 2 (ME3BB)

1. Advance Engineering Materials: ME322
2. Energy and Exergy Analysis of Thermal Systems: ME324
3. Machine Tool Design: ME326
4. Micro-Hydro Power Plant: ME328
5. Micro and Nano-Manufacturing: ME332
6. Finite Element Methods: ME334

Core Elective – 3 (ME3CC)

1. Renewable Energy Systems: ME431
2. Mechanics of Composite Materials: ME433
3. Gas Dynamics: ME435
4. Fatigue, Fracture and Failure Analysis: ME437
5. Robotics: ME438
6. **Innovation, Incubation and Entrepreneurship (Course will be taught by Department of Mathematics and Humanities)**

Tribology and Mechanical Vibrations

ME302

L	T	P	Credit
3	1	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Get knowledge of basics & priniciples of Tribology.
CO2	Understand the concept about friction and wear in engineering apllications.
CO3	Analyze the concept of hydrodynamic, hydrostatic, hydrostatic squeeze lubrications, Hydrodynamic and Thrust Bearings.
CO4	Understand different methods to determine natural frequency of systems.
CO5	Evaluate natural frequencies for Free Damped linear and tornsnal Systems
CO6	Investigate the frequencies for Forced Vibration linear and rotational Systems

2. Syllabus

- **INTRODUCTION** **(05 Hours)**

Definition of tribology, friction, wear and lubrication, importance of the Tribological studies. Surface Topography: Methods of assessment, measurement of surface roughness-different statistical parameters (Ra, Rz, Rmax, etc.), contact between surfaces, deformation between single and multiple asperity contact, contact theories involved

- **FRICTION** **(05 Hours)**

Coulomb and Amontons laws of friction, its applicability and limitations, comparison between static, rolling and kinetic friction, friction theories, mechanical interlocking, molecular attraction, electrostatic forces and welding, shearing and ploughing, models for asperity deformation.

- **LUBRICATION** **(06 Hours)**

Types of lubrication, viscosity, characteristics of fluids as lubricant, hydrodynamic lubrication, Reynold's equation, elastohydrodynamic lubrication- partial and mixed, boundary lubrication, various additives, solid lubrication.

- **WEAR** **(06 Hours)**

Sliding wear: Abrasion, adhesion and galling, testing methods pin-on-disc, block-on ring, etc., theory of sliding wear, un-lubricated wear of metals, lubricated wear of metals, fretting wear of metals, wear of ceramics and polymers. Wearing by plastic deformation and brittle fracture. Wear by hard particles: Two-body abrasive wear, three-body abrasive wear, erosion, effects of hardness shape and size of particles.

- **FUNDAMENTALS OF VIBRATIONS** **(03 Hours)**

Introduction, definition, SHM, beats phenomenon, complex method of representing harmonic vibrations

- **UNDAMPED FREE VIBRATIONS OF SINGLE DEGREE OF FREEDOM SYSTEM**

Introduction, deviation of differential equations and resolution, equivalent stiffness of spring combinations, Newton's method and energy method for problem solutions. **(04 Hours)**

- **DAMPED FREE VIBRATIONS OF SINGLE DEGREE OF FREEDOM SYSTEM**

Different types of damping, free vibrations with viscous dampers **(05 Hours)**

- **FORCED VIBRATION OF SINGLE DEGREE OF FREEDOM SYSTEMS(05 Hours)**

Forced vibration with constant harmonic excitation, with rotating and reciprocating unbalance, due to the support, vibration isolation and transmissibility, measuring instruments, displacement, velocity, acceleration, frequency measuring instruments.

- **CRITICAL SPEED OF SHAFTS (03Hours)**

Introduction, critical speed of shaft having single and multiple disc

(Total Lecture Hours: 42)

---

3. Practicals:

1. Tuned rectilinear vibration absorber
2. Rectilinear vibration of cantilever beam
3. Free damped vibration
4. Fixed free three rotor system
5. To determine the viscosity using falling ball viscometer
6. Demonstrate friction and wear measurement on pin on disc apparatus
7. Demonstrate the coefficient of friction measurement on reciprocation motion
8. Performance of Journal bearing test rig
9. To measure the surface roughness using profile-meter

4. Books Recommended:

1. R. D. Arnell, P. Davies, J. Halling, and Terence Whomes, Tribology: Principles and Design Applications: Principles and Design Applications, Macmillan International Higher Education, 1991.
2. B. C Majmudar, Introduction to Tribology of Bearings, S Chand & Company, 2010.
3. B. Bhushan, Introduction to Tribology, 2nd Edition, Wiley-Blackwell, 2013.
4. S. S. Rao, Mechanical Vibrations, Pearson Education, 6th Edition, 2018.
5. G. K. Grover, Mechanical Vibrations, Nem Chand & Bros, 2009.

Production Technology

ME304

L	T	P	Credit
3	0	2	04

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the tool nomenclature, tool materials, cutting forces and heat distribution during machining.
CO2	Analyze tool life, tool wear and failure analysis of cutting tools.
CO3	Determine the optimum value of parameters by using economics of machining.
CO4	Explain various types of thread and gear manufacturing processes.
CO5	Explain various unconventional machining processes, their capabilities and limitations.
CO6	Apply the knowledge of kinematics of machine tools, machine tool controls and tool layout for automats.

2. Syllabus

- **INTRODUCTION TO METROLOGY** **(04 Hours)**
  Definition of metrology, important terms such as error, zero error, accuracy, precision, sensitivity, true value, Classification of methods of measurement, Uncertainty of measurement.

- **LIMITS, FITS, AND GAUGES** **(08 Hours)**
  Limit, Fit, Types of fit, Tolerance, Tolerance analysis, Interchangeability, Types of gauges, Design of limit gauges.

- **MEASUREMENT** **(08 Hours)**
  Measurement of length, angle and taper; Screw thread measurement, Gear measurement, Surface roughness measurement, Geometrical Dimensioning and Tolerancing (GD & T).

- **INTRODUCTION TO METAL FORMING** **(04 Hours)**
  Plastic deformation and yield criteria, Material behavior in metal forming processes, Role of temperature in in forming processes, Classification of metal forming processes.

- **MECHANISM OF METAL FORMING PROCESSES** **(10 Hours)**
  Mechanism of bulk deformation processes (rolling, forging, wire drawing, and extrusion) and sheet metal forming processes, Applications of metal forming processes, Mechanism and applications of high energy rate forming processes,

- **ANALYSIS OF BULK DEFORMATION PROCESSES** **(08 Hours)**
  Analysis of forging, rolling, drawing, and extrusion process

(Total Lecture Hours: 42)

3. Practicals:

1. To calibrate given indicating micrometer/micrometer.
2. To find angle of V-block, dovetails, taper, and radius of circular arc.
3. To calibrate given gear tooth vernier, find the tooth thickness and module
4. To find the pitch, effective diameter, best wire size of the given screw threads,
5. To find the angle of external taper, taper of tapered hole, taper of tapered ring.
6. To draw stress-strain behavior for model material.
7. To measure the force required in extrusion.
8. To find flow stress of the given material and to plot a graph of forging ratio vs flow stress

4. Books Recommended:

1. A. K. Bewoor and V. A. Kulkarni, Engineering metrology and measurements, Tata McGraw Hill Education, 2017.
2. N. V. Raghavendra, L. Krishnamurthy, Engineering Metrology and Measurements, Oxford publishers, 2013.
3. R. K. Jain, Engineering Metrology, Khanna Publishers, 1997.
4. S. Kalpakjian, S. R. Schmid, Manufacturing Engineering and Technology, 7th Edition, Pearson, 2018
5. A. Ghosh and A. K. Mallik, Manufacturing Science, East West Press New Delhi, 2010.

Applied Thermal Engineering

ME306

L	T	P	Credit
4	0	2	05

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Correlate the suitability of particular fuel for SI/CI engines.
CO2	Compare the working and performance of CI and SI engines.
CO3	Prepare heat balance sheet and calculate SI/CI engine efficiencies.
CO4	Evaluate the refrigeration systems for various applications.
CO5	Determine the properties of moist air and present air conditioning processes on Psychrometric chart.
CO6	Compute cooling/heating loads for designing air conditioning systems, cold storage plants.

2. Syllabus

- **INTRODUCTION TO INTERNAL COMBUSTION ENGINES (03 Hours)**

Historical Development in IC Engines, General Specifications of I C Engines being used for Two Wheeler, Three Wheeler, Four Wheeler segment.

- **FUEL AIR CYCLE AND ACTUAL CYCLE ANALYSIS (05 Hours)**

Significance of cycle analysis. Effect of variation in specific heat of gases, Dissociation effect, Time burning Loss and other losses affecting the performance of engine cycle. Comparison of air standard cycle-fuel air cycle and actual cycle analysis.

- **COMBUSTION IN SI AND CI ENGINE (12 Hours)**

Stages of combustion in SI Engine, Factors affecting various stages of combustion in SI Engine, Stages of combustion in CI Engine, delay period, factors affecting stages of combustion in C I Engine, Difference of Ignition Delay and ignition lag, Abnormal combustion phenomenon in SI and CI engine and its prevention. Knocking/detonation and its effects, Comparison of normal and abnormal combustion in SI and CI Engines.

- **ENGINE EMISSION AND CONTROL (05 Hours)**

Pollutant - Sources and types – Effect on environment and human health - formation of NOx - Hydrocarbon Emission Mechanism - Carbon Monoxide Formation - Particulate emissions - Methods of controlling Emissions - Catalytic converters and Particulate Traps - Selective Catalytic Reduction(SCR) - Diesel Oxidation Catalyst (DOC). - Emission Norms and Driving cycles - Indian and Euro norms.

- **GAS TURBINE POWER PLANT (03 Hours)**

Introduction to Gas Turbine, Site Selection, Components and Layout, Performance analysis of Brayton Cycle; open cycle and closed cycle gas turbine power plant.

- **AIR REFRIGERATION (04 Hours)**

Reversed Carnot cycle, Bell Coleman cycle, Aircraft refrigeration cycle, Boot strap system, Actual cycle, Ramming, Compression and Turbine efficiencies, Coefficient of performance.

- **VAPOUR COMPRESSION REFRIGERATION (07 Hours)**

Simple vapour compression cycle, Analysis of vapour compression cycle, Modifications and performance improvements to simple vapour compression system, Multistage vapour compression system, properties of refrigerants.

- **VAPOUR ABSORPTION REFRIGERATION (03 Hours)**

Comparison between vapour absorption and vapour compression system, Aqua-Ammonia and Lithium Bromide absorption system.

- **PSYCHROMETRY OF AIR CONDITIONING PROCESSES (14 Hours)**

Psychrometric properties, Preparation of psychrometric charts, Psychrometric Processes - Mixing process, Sensible heating, Sensible cooling, Humidification, Dehumidification, Cooling and Dehumidification, Heating and humidification, Bypass factor, Apparatus dew point, Sensible heat factor, Air washer, evaporative cooling, Adiabatic humidification, Efficiency of humidification, Summer and Winter air conditioning system, Load calculations, comfort conditions, Central air conditioning plant, Pressure drop in air ducts.

(Total Lecture Hours: 56)

---

3. Practicals: (Any 5 Practical from S. No. 1 to 7; and other 5 Practical from S. No. 8 to 14)

1. Study of Valve Timing/Port Timing Diagram for Engine System
2. Performance test of 4 stroke Petrol Engine.
3. Performance test of 4 stroke Diesel Engine.
4. Heat Balance Preparation for 4 stroke Diesel Engine.
5. Heat Balance Preparation for 4 stroke Petrol Engine
6. Determination of friction power of multi cylinder petrol engine using Morse Test Method.
7. Determination of friction power of single/multi cylinder petrol engine using Willan's Line Method.
8. To conduct performance test on vapour compression refrigeration system.
9. To study tools and instruments used in refrigeration and air conditioning
10. To determine psychrometric properties of air.
11. To conduct performance test on air conditioning system
12. To conduct performance test on Ice plant.
13. To conduct performance test on vapour absorption system - Electrolux- Domestic type.
14. To conduct performance test on desert cooler.

4. Books Recommended:

1. V. Ganesan, Internal Combustion Engine, Fourth Edition, Tata Mc-Graw Hill, 2017.
2. M.L. Mathur and R.P. Sharma, Internal Combustion Engine, Dhanpat Rai Publications, 2010.
3. R. Stone, Introduction to Internal Combustion Engines, Fourth edition, Palgrave Macmillan, 2012.
4. R. J. Dossat, Principles of Refrigeration, Pearson Education India, 2002.
5. C. P. Arora, Refrigeration and Air conditioning, Tata McGraw Hill, 2017.

Corrosion Engineering

ME362

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe importance of corrosion and various terminology associated with corrosion.
CO2	Identify various types of corrosion, significance, causes and remedies.
CO3	Interpret corrosion issues of various grades of materials.
CO4	Analyze effect of different environments and conditions on corrosion behavior.
CO5	Predict and test corrosion rate of materials from available data.
CO6	Apply design guidelines and preventive methods to minimize corrosion of materials.

2. Syllabus

- **INTRODUCTION TO CORROSION (04 Hours)**

Definition, corrosion damage, statistics/summary of losses due to corrosion, importance of corrosion control, corrosion rate expressions, standards/societies related to corrosion, NACE terminology, origin of Pourbaix diagram.

- **TYPES OF CORROSION (07 Hours)**

General corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching, erosion corrosion, stress corrosion, overview of hydrogen cracking, high temperature corrosion. Case studies of failures due to various types of corrosion.

- **CORROSION OF VARIOUS MATERIALS (08 Hours)**

Corrosion of carbon steels, stainless steels and alloy steels. Corrosion issues of aluminium, magnesium, copper, nickel, titanium, etc. and its alloys. Corrosion issues of composite materials and its control.

- **CORROSION IN SELECTED ENVIRONMENTS AND ITS CONTROL (09 Hours)**

Atmospheric corrosion, corrosion due to sea water, microbiologically induced corrosion, overview of corrosion in human body, overview of corrosion in automobiles, overview of corrosion in aircraft, corrosion of steel in concrete, corrosion in petrochemical industry, corrosion in paper and pulp industry and its control.

- **CORROSION TESTING (08 Hours)**

Purpose of testing, importance of testing, laboratory, semi-plant and field tests, ASTM standards for testing, material selection and sample preparation, sequential procedure for laboratory and on-site corrosion investigations. Various tests like immersion tests, cabinet tests, Huey test, Streicher test, Warren test, slow strain rate test, electrochemical tests, high temperature and pressure test, paint test, etc. Testing of stress corrosion cracking and pitting. Cases studies for failure analysis related to surface degradation.

- **CORROSION PREVENTION (06 Hours)**

Purification and alloying of metal, material selection, alteration of environment, design modifications, cathodic and anodic protection, coatings (metallic, inorganic, non-metallic and organic)

(Total Lecture Hours: 42)

3. Books Recommended:

1. M. G. Fontana, Corrosion Engineering, 3rd Edition, Tata McGraw-Hill, 2005.
2. R. W. Revie and H. H. Uhlig, Corrosion and Corrosion Control: An Introduction to Corrosion Science and Engineering, 4th Edition, Wiley Publication, 2008.
3. R. Baboian, Corrosion Tests and Standards: Application and Interpretation, 2nd Edition, ASTM International, 2005.
4. E. Bardal, Corrosion and Protection, 1st Edition, Springer-Verlag London Ltd., 2004.
5. A. J. McEvily and J. Kasivitamnuay, Metal Failures: Mechanisms, Analysis, Prevention, 2nd Edition, Wiley Publication, 2013.

Energy Efficiency and Industrial Utilities

ME364

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Apply various energy conservation techniques to estimate energy saving potential
CO2	Provide solutions for energy conservation in boiler systems and furnaces through analysis and applications of improved refractories and insulations
CO3	Compare various appliances/utilities based on their stars and labelling, benchmarking values
CO4	Calculate the usage of energy for a given industrial utility and suggest suitable way to minimize energy bill
CO5	Relate the significance of energy usage in buildings and understand the ways to reduce energy bill
CO6	Compute various performance parameters of HVAC systems and suggest suitable ways for improving energy efficiency

2. Syllabus

- **GLOBAL AND NATIONAL ENERGY SCENARIO (05 Hours)**

Energy consumption in various sectors, Energy resources like Coal, Oil and Natural Gas –their demand and supply management, Indian energy scenario, Indian Coal & LPG scenario, Primary and Secondary Sources of Energy, Commercial and Non Commercial Sources, India's installed energy capacity, per capita energy consumption, General aspects of Energy conservation and management, Roles of energy auditors, Roles of energy manager, Energy policy of industry, Energy Conservation Act and its amendments

- **ENERGY EFFICIENCY IN BOILER, STEAM AND FURNACE SYSTEM UTILITIES (10 Hours)**

Energy conservation opportunities in boiler systems, retrofitting of FBC in conventional boilers, Steam line distribution standard practices including sizing and layouts, selection, operation and maintenance of steam traps, energy saving opportunities in steam systems

Energy Efficiency in Furnaces: Sankey diagram, Fuel economy measures in furnaces

Insulation and Refractories: Types of insulations, Economic thickness of insulation, Typical refractories for industrial applications

- **COGENERATION (03 Hours)**

Principle of cogeneration, Technical options for cogeneration, Factors influencing cogeneration choice, Important technical parameters for cogeneration, case study on savings with and without cogeneration

- **FANS, BLOWERS AND COMPRESSORS AND PUMP SYSTEMS (12 Hours)**

Energy saving opportunities, performance evaluation and efficient system operation.

Compressed Air Systems: Efficient operation of compressed air system, Leakage tests.

Pumps and Pumping Systems: Pump curves, factors affecting pump performance, Energy loss in throttling, Effects of impeller diameter change, Flow control strategy, Variable speed drives, Energy conservation opportunities.

- **ENERGY EFFICIENCY IN HVAC AND REFRIGERATION UNITS (04 Hours)**

Performance assessment of refrigeration units, Factors affecting energy efficiency in refrigeration plants, Energy saving opportunities in cold storage systems, Heat Pumps and Applications, Standards and Labelling of Room Air-conditioners.

- **COOLING TOWERS (02 Hours)**

Performance evaluation and assessment, Efficient system operation, Energy saving opportunities.

- **LIGHTING SYSTEMS (02 Hours)**

Light source and Lamp types, Illuminance level for various tasks, Energy efficient lighting controls, standards and labelling programs in lamps.

- **ENERGY CONSERVATION IN BUILDINGS (04 Hours)**

Energy Conservation Building Codes, ECBC Guidelines on Building Envelops, service hot water, lighting, water pumping, electrical power, escalators and elevators, Star Ratings of buildings.

(Total Lecture Hours: 42)

3. Books Recommended:

1. General Aspects of Energy Conservation, Management and Audit: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
2. Energy Efficiency in Electrical Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
3. Energy Efficiency in Thermal Utilities: Guide Book for Energy Managers and Energy Auditors; Bureau of Energy Efficiency, Ministry of Power
4. S. A. Roosa, Energy Management Handbook, Fairmont Press, 2018
5. A. Thumann, Handbook of Enegry Audits, Fairmont Press, 2012

Product Design and Development

ME366

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental requirement of product design
CO2	Describe the concepts of design and intellectual rights for innovation
CO3	Explain the concepts of design for manufacturing and industrial design aspects
CO4	Design and model the product
CO5	Apply the concept of product life cycle and management to design product
CO6	Develop new services or products based on consumer's need analysis, market research and feasibility studies.

2. Syllabus

- **MOTIVATION/OBJECTIVE OF PRODUCT DEVELOPMENT (14 Hours)**

Customers' need analysis, Market research & feasibility study, New Product Development (NPD) or improving the existing product, Product Design Specifications (PDS), Quality Function Deployment (QFD) technique

- **DESIGN ENGINEERING (18 Hours)**

Conceptual design; concept generation, selection, and testing. Creating design ideas & Problem solutions. Methodologies; brain storming, lateral thinking, Theory of Inventive Problem Solving (TRIZ), Use of available products and literature (patents & copy rights),
Preliminary design; design considerations, product architecture, functional dimensions and useful life for the application. Concept of reverse engineering, Design for X (DfX), manufacturing, assembly, material selection, reliability & value engineering, Industrial design (human factors); ergonomics safety, aesthetics,
Detail design & documentation; parts and assembly drawings, design and review reports. Modeling/Prototyping and performance testing.

- **LAUNCHING AND LIFE CYCLE MANAGEMENT (10 Hours)**

Reaching out to customers; Marketing, advertising, promoting, servicing etc, Product life cycle and management.

(Total Lecture Hours: 42)

3. Books Recommended:

1. K. T. Ulrich, S. D. Eppinger, and M. C. Yang , Product Design & Development, , 7th Edition, McGraw Hill, 2019.
2. G. Pahl, W. Beitz, J. Feldhusen and K. Grote, Engineering Design - A Systematic Approach, 3rd Edition Springer, 2007.
3. L. C. Schmidt and G. Dieter, Engineering Design, 4th Edition, Mc Graw Hill, 2017.
4. Y. Haik, Engineering Design Process, 2nd edition, CL Engineering, 2011.
5. J. G. Bralla, Hand book of Product Design for Manufacturing, 2nd edition, McGraw Hill, 1996.

Lubrication Technology

ME368

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain basics of lubricants, primary roles, their types, performance properties and evaluation methods.
CO2	Apply the conceptual selection criteria of lubricants in the industrial applications.
CO3	Identify oil degradation; role of various additives; selection criteria for lubricants in various situations; various regimes of lubrication and Stribeck curve
CO4	Explain the theory of lubrication in industrial applications.
CO5	Explain the general safety considerations for lubrication storage and handling of the plants.
CO6	Design and develop lubricants for novel and diverse applications

2. Syllabus

- **INTRODUCTION** **(08 Hours)**

Introduction: friction, wear and lubrication, Historical background, Purpose of lubrication, Lubrication regimes, Characteristics of lubricants - viscosity, viscosity index, oxidation stability, flash point and fire point, pour point and cloud point, carbon residue, ash content, iodine value, neutralization number, dielectric strength.

- **LUBRICANTS** **(08 Hours)**

Classification of lubricating oils, properties of lubricating oils, tests on lubricants. Grease classification, properties, tests. Specific requirements for automotive lubricants, oxidation, deterioration and degradation of lubricants, additives, synthetic lubricants.

- **PROPERTIES AND ADDITIVES** **(10 Hours)**

Composition and classification of lubricants, lubricating oils – oil refining, types, categories, grading, Grease - composition, function, characteristics, thickeners and additives, soap and its complexes, selection and its practices, solid lubricants, Functional additives – surface, performance enhancing, lubricant protective.

- **THEORY OF LUBRICANTS** **(10 Hours)**

Engine friction - introduction, total engine friction, effect of engine variables on friction, hydrodynamic lubrication, elastohydrodynamic lubrication, boundary lubrication, bearing lubrication, functions of the lubrication system, introduction to design of a lubricating system.

- **LUBRICANTS APPLICATIONS** **(06 Hours)**

Tribological components and industrial machinery, Lubricants testing and test methods, Organization and management of lubrication, lubricant storage and handling, Safety and health hazards, Environmental regulations.

(Total Lecture Hours: 42)

3. Books Recommended:

1. Hand Book of Lubrication and Tribology, Vol. I – Vol. III, CRC Press Inc., 2006
2. D. D. Fuller, Theory and practice of lubrication for engineers,2nd Edition, John Wiley & sons., 1984
3. A. Cameron, Basic Lubrication Theory, Prentice Hall Press, 1971
4. Raymond G. Gunther, Lubrication, Chipton Book Co., 1971
5. A. R. Lansdown, Lubrication &Lubricants selection, 3rd Edition, ASME Press, 2003

Plant Layout and Material Handling

ME372

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Demonstrate the capabilities of selecting suitable plant location considering various criteria.
CO2	Demonstrate the knowledge of factory buildings used in industries and its importance.
CO3	Explain the various types of plant layouts used in industries
CO4	Analyze various types of plant layouts used in industries and solve the related problem
CO5	Evaluate the optimum layouts using optimization techniques.
CO6	Analyze and identify suitable material handling equipment used in industries as per the requirement.

2. Syllabus

- **INTRODUCTION** (**04 Hours**)

  Need of plant layout; basic objectives of plant layout; types of plant layouts; types of production systems.

- **PLANT LOCATION** (**06 Hours**)

  Introduction to plant location, Influence of location on plant layout, plant location selection factors, Models for the plant location selection: median model, gravity model; plant location selection

- **INDUSTRIAL BUILDING** (**04 Hours**)

  Relationship between the building and layout, considerations in industrial building design; types of factory buildings: single storey/horizontal buildings and multi storey buildings.

- **PLANT LAYOUT** (**06 Hours**)

  Definitions of plant layout, types of plant layouts: product Layout, process layout/functional type layout, fixed position layout, group technology layout/cellular layout; advantages and disadvantages.

- **EVALUATION OF LAYOUTS** (**15 Hours**)

  Product layout/assembly line evaluation algorithms: largest candidate rule; Kilbridge and Wester method; ranked positional weights method. Process layout evaluation: qualitative and quantitative factors; layout cost evaluation; comparing two layout layout; computerized relative allocation of facilities technique (CRAFT); equal area and unequal area facility layout problems. Assignment model for addition of new facilities/machine to the existing layout. Group technology layout evaluation: part families and machine cells; rank order clustering technique.

- **MATERIAL HANDLING** **(07 Hours)**

  Principles of material handling, Factors considered for material handling equipment selection, Types of material handling equipment: load formation equipment, positioning equipment,

conveyers, cranes and hoists, industrial trucks, elevators, storage equipment, etc.; material handling equipment selection.

(Total Lecture Hours: 42)

---

3. Books Recommended

1. M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2018.
2. R. Panneerselvam, Production and Operations Management, 3rd Edition, Prentice Hall India, 2012.
3. T. H. Allegri, Material Handling, Principles and Practice, CBS Publishers, New Delhi, 2017.
4. P.B. Mahapatra, Computer Aided Production Management, 1st Edition, Prentice Hall India, 2004.
5. S. Roy, Introduction to Material Handling, 2nd Edition, New Age International (P) Ltd, 2017.

Risk, Reliability and Life Testing

ME374

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Examine the reliability of any product or system which ultimately maintains the customers' base of any industry.
CO2	Explain the components and systems through its life cycle.
CO3	Evaluate the probabilistic time analysis of products' successes and failures.
CO4	Predict reliability of any component or system which is essential before we put it into any use.
CO5	Estimate the life of a system and their components with concepts of highly accelerated life testing.
CO6	Improve reliability of a system using different reliability improvement techniques.

+

2. Syllabus

- **BASIC CONCEPTS IN RELIABILITY (08 Hours)**

Risk and Reliability, introduction and fundamentals of risk management and reliability engineering, bath tub curve, failure mechanism of mechanical components: causes, modes, function of mechanical elements, failure theories.

- **COMPONENT RELIABILITY (06 Hours)**

Failure data analysis, reliability function, hazard rate, failure rate, and their relationship, MTTF, mean failure rate, MTBF.

- **SYSTEM RELIABILITY (06 Hours)**

Series, parallel, mixed configuration, r-out of-n structure, solving complex systems, Reliability Logic Diagrams (RLD), techniques of reliability estimation: fault tree analysis, tie sets and cutsets, boolean algebra.

- **SYSTEM RELIABILITY IMPROVEMENT (08 Hours)**

Use of better components, simplification, derating, redundancy, working environment control, maintenance, etc. redundancy techniques: introduction, component vs unit redundancy, weakest link technique, mixed redundancy, standby redundancy, redundancy optimization, double failure and redundancy.

- **CASE APPLICATION OF COMPLEX SYSTEM (04 Hours)**

Marine power plant, computer system, nuclear power plant, combats aircraft, etc.

- **RELIABILITY TESTING (08 Hours)**

Introduction, objectives, assumptions, different types of test. life testing in practice: methodology, problems and difficulties. economics of reliability engineering.

- **ACCELERATED LIFE TESTING** **(10 Hours)**

Introduction, basic concepts, data qualification. accusations faster, stress combination methods, limitations, Accelerated Stress Testing (AST), step stress method for AST, various AST models, recent development recommended approach. Highly Accelerated Life Testing (HALT), Highly Accelerated Stress Screening (HASS).

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. L. S. Srinath, Mechanical Reliability, East-West Press Pvt. Ltd, New Delhi, 2002
2. L. S. Srinath, Reliability Engineering, 4th edition, East-West Press Pvt. Ltd, New Delhi, 2005
3. V. N. A. Naikan, Reliability Engineering and Life Testing, PHI Learning Pvt. Ltd. New Delhi, 2008
4. E. Balagurusamy, Reliability Engineering, TMH, New Delhi, 2017
5. D. T. Patrick, Practical Reliability Engineering, 4th edition, Wiley Publishing company, 2008

.

Materials Management

ME376

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Describe the role and scope of materials management in organization.
CO2	Apply the concepts of classification, codification, specification, standardization and variety reduction for proper store management.
CO3	Design and develop standard specifications for machines or components
CO4	Apply deterministic and probabilistic inventory control models and selective inventory control to ensure a steady supply of materials to meet the needs of the organization
CO5	Evaluate the budget and material requirement plan to insure a steady supply of materials to meet the needs of the organization
CO6	Develop key characteristics of fundamental and specialized purchasing aspects, store keeping, the public and international purchases.

2. Syllabus

- **MATERIALS MANAGEMENT** (**04Hours**)

  Functions, Objectives, Activities, Cost, advantages, Desirable qualities of purchasing and materials manager

- **CLASSIFICATION, CODIFICATION & SPECIFICATION** **(05 Hours)**

  Need for classification and identifications of materials. Classification of Materials, Codification: Nature, process, merits and demerits, Codification Systems, Stores Vocabulary, Marking of Stores, Objective of specifications, Specification Categories and development

- **STANDARDISATION AND VARIETY REDUCTION** **(05 Hours)**

  Standard, Dimensions, Different levels of standards, Scope, Various foreign standards used in India, Procedure for evolving Indian standards, Benefits, Standardization and variety reduction in products, Techniques of variety reduction, Three S's- Standardization, Simplification and Specialization

- **INVENTORY CONTROL AND MANAGEMENT** **(07 Hours)**

  Classification, Inventory Models (Deterministic and Probabilistic), P and Q Systems in Practice, Selective Inventory Control, Two dimensional Classification, Music 3-D Model, A-B-C analysis for always better control.

- **BUDGETING AND MATERIAL RESOURCE PLANNING** **(07 Hours)**

  Budgetary control, Types, advantages, Material Requirement Planning (MRP) structures, Management, Lot sizing techniques

- **STORE AND STORE KEEPING** **(04 Hours)**

  Objectives, Functions of storekeeper, Benefits of store keeping, Features of successful store keeping, Stores Organization, Location and layout of stores, Types of stores, Stock taking

- **PURCHASING** **(10 Hours)**

  Purchasing Process, purchasing terms and conditions, Principles, Objectives, Methods, Vendor/Supplier rating, e-Procurement, Vendor/Supplier performance evaluation, negotiation, make or buy, outsourcing, and buy commodities, capital goods, Director general of Supplies and Disposals (DGS&D), Supplier registration, Government e-Market place (GeM), tendering, Central Public Procurement Portal (CPPP), Director general of foreign trade (DGFT), Importers, Criteria of Licencing, Negative list, Import procedure

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. J. R. T. Arnold, S. N. Chapman and L. M. Clive, Introduction to Materials Management, 7th Edition,Pearson Education, 2010.
2. A. K. Chitale and R. C. Gupta, Materials Management: A Supply Chain Perspective, 3rd Edition, PHI learning Private Limited, 2014.
3. J. Heizer, B. Render, C. Munson and A. Sachan, Operations Management, 12th Edition, Pearson Education, 2017.
4. P. Gopalakrishnan and A. Haleem, Handbook of Materials Management, 2nd Edition, Prentice Hall India Learning Private Limited, 2015.
5. P. Gopalakrishnan and M. Sundaresan, Materials Management: An Integrated Approach by Gopalakrishanan, 1st Edition, Prentice Hall India Learning Private Limited, 1977.

Advanced Engineering Materials

ME322

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain major types of special steels, their properties and applications
CO2	Find out metals that can be used for high temperature applications
CO3	Select cast-irons for specific engineering applications
CO4	Correlate metallurgical aspects and application of light metals
CO5	Select nanomaterials for different industrial applications
CO6	Describe material properties and select the suitable material for biological, space and cryogenic service applications

2. Syllabus:

- **INTRODUCTION** **(01 Hour)**
  The urge for advancements in material development and processing.

- **SPECIAL STEELS** **(08 Hours)**
  Metallurgical aspects, Composition, Properties and applications of: different types of Stainless steels, Dual phase steels, TRIP steels, Maraging steels, High speed steels, Hadfield steels, Free cutting steels, Ausformed steels, Tool Steels, manganese steels, chrome steels, electrical steels, bearing steels, spring steels, heat resistant steels, creep steels, HSLA steels, materials in nuclear field, materials used in space

- **SPECIAL AND HIGH TEMPERATURE ALLOYS** **(06 Hours)**
  Ti alloys: physical and mechanical properties, thermomechanical treatment of Ti-alloys, Ti shape memory alloys, Fe based super alloys, Ni based alloys, Co based alloys, Strengthening mechanism, Composition, Properties and their applications. engineering applications at elevated temperatures.

- **ALLOY CAST IRON** **(05 Hours)**
  Austempered ductile iron; alloy cast irons, Ni hard, high silicon cast irons, heat resistant cast irons- high chrome cast iron- structure, property and engineering applications.

- **LIGHT METALS AND THEIR ALLOYS** **(04 Hours)**
  Aluminium, magnesium and titanium alloys: Metallurgical aspects, Properties and applications.

- **NANO MATERIALS** **(04 Hours)**
  Definition, Types, Properties and applications, Carbon nano tubes, Methods of production.

- **SMART MATERIALS AND BIOMATERIALS** **(06 Hours)**

Shape memory alloys, Piezoelectric materials, Electro-rheological fluid, Magneto-rheological fluids,biocompatibility, bio functionality, Important bio metallic alloys like: Ni-Ti alloy and Co-Cr-Mo alloys. Applications.

- **COMPOSITE MATERIALS** **(04 Hours)**
  PMC, CMC, MMC, processing and typical application**,** Special High Temperature High performance Carbon-Carbon composites.

- **MISCELLANEOUS ADVANCED MATERIALS** **(04 Hours)**
  Magnetic materials, aerospace materials, cryogenic materials, semi-conducting and superconducting materials.

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. J. F. Shackelford, B. R. W. Alexander, Materials Science and Engineering Handbook, CRC Press, LLC, 2001.
2. K. G. Budinski, M K Budinski, Engineering Materials: Properties and Selection, General Motors Corporation, Pearson, 2010.
3. I. J. Polmear, Light alloys: Metallurgy of Light Metals, Arnold, 1995.
4. Z. Abdullaeva, Nano and Biomaterials: Compounds, Properties, Characterization and Applications, Wiley-VCH Verlag, 2017.
5. K K Chawla, Composite Material Science and Engineering, Springer, 2012.

Energy and Exergy Analysis of Thermal Systems

ME324

L	T	P	Credit
3	0	0	3

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the importance of the exergy and its difference from energy analysis
CO2	Apply the first law and second law of thermodynamics to various thermal systems
CO3	Determine the physical and chemical exergy of a given system
CO4	Illustrate pictorial representation of exergy balance
CO5	Perform exergy analysis of different thermal systems
CO6	Apply exergy analysis knowledge to thermal systems to improve the overall performance of plant.

2. Syllabus

- **Introduction** **(05 Hours)**

Fundamentals of mass, energy and entropy balance, and requirement of exergy analysis

- **Basics of exergy analysis** **(10 Hours)**

Energy and exergy analysis, Exergy classifications, Exergy of closed systems, Exergy of flows, Exergy consumption, Procedure for energy and exergy analysis, reference environment, Exergy analysis implications

- **Exergy analysis of thermodynamic processes** **(10 Hours)**

Mixing and separation process, heat transfer across a finite temperature difference, expansion and compression processes, Chemical process in combustion.

- **Elements of plant analysis** **(05 Hours)**

Control mass analysis, control region analysis, Criteria of performance, Pictorial representation of exergy balance, Energy and exergy properties diagram

- **Exergy analysis of thermal power plants** **(12 Hours)**

Gas turbine power plant with external and internal irreversibility, regeneration, cogeneration, reheater, and intercooler, combined steam and gas turbine power plant, Brayton cycle steam turbine power plants with external and internal irreversibility, super heater, reheater, vacuum condenser, regenerative feed water heating, combined feed water heating and reheating. Combined power plants

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. A. Bejan, G. Tsatsaronis, M. J. Moran, M. Moran, Thermal Design and Optimization, John Wiley & Sons, Inc.. 1996
2. I. Dincer Marc A. Rosen, Exergy, Energy, Environment and Sustainable Development, Elsevier Science, 2013
3. A. Bejan, Advanced Engineering Thermodynamics, John Wiley & Sons, Inc., New York. 2016
4. T. J. Kotas, The exergy Method of Thermal Plant Analysis, Butterworth-Heinemann, 2013
5. M. J. Moran, Availability Analysis – A Guide to Efficient Energy Use, ASME, 1989

Machine Tool Design

ME326

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the general requirements of machine tools.
CO2	Design mechanical and hydraulic transmission elements.
CO3	Analyze the kinematics of machine elements
CO4	Explain machine tool control systems.
CO5	Design the column, table and guide ways of machine tools.
CO6	Design and develop control systems for machine tools

2. Syllabus

- **INTRODUCTION** **(03 Hours)**

General requirements to machine tools, Machine tool design recommendations, Classification of motions to shape surface, Machine tool drives for rectilinear motion, Periodic motion, reversing motion etc.

- **KINEMATICS OF MACHINE TOOLS** **(05 Hours)**

Kinematics or gearing diagram of Lathe, Drilling Machine, Milling Machine etc. machine tool drive, principles specification of machine tool.

- **DESIGN OF KINEMATICS** **(05 Hours)**

Methods to determine transmission ratios for drives, Mechanical transmission and its elements, hydraulic transmission and its elements.

- **SPEED AND FEED BOXES** **(05 Hours)**

General requirement, Design of gear trains, speed box es types, speed changing devices, feed boxes, characteristics of feed mechanism, types of rapid traverse mechanisms, variable devices

- **SPINDLE DESIGN AND SPINDLE BEARING** **(08 Hours)**

Main requirement, Materials and details of spindle design, Spindle bearings, bearings, types of bearings and their selections, Bearing Materials

- **COLUMNS, TABLES AND WAYS** **(08 Hours)**

Materials, typical constructions and design, basic design procedure of machine tool structure, design of columns, function and types of guide ways, design criteria and calculation of slide ways.

- **MACHINE TOOLS CONTROL SYSTEMS** **(08 Hours)**

Requirement of control system selection and construction of control systems Mechanical control system, predilection control, remote control safety devices

(Total Lecture Hours: 42)

3. Books Recommended:

1. N. K.Mehta, Machine Tool Design, 3re Edition, Tata McGraw Hill, 2017
2. S. K.Basu and D. K.Pal, Design of Machine Tools, 5th Edition, Ox ford and IBH, 2005
3. N. Achertan, Machine Tool Design, University Press of the Pacific, 2000
4. F. Koenigsberger, Design Principles of Metal Cutting Machine Tools, Pergamon Press, 2013
5. G. C.Sen and A.Bhattacharyya, Principles of Machine Tools, 2nd Edition, New Central Book Agency,2009

Micro-Hydro Power Plant

ME328

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of hydro-electric power plant and classify different hydro-electric and micro hydro-electric power plant
CO2	Analyze flow prediction methods and evaluate flow transfer systems required based on site conditions
CO3	Identify different types of turbines and analyze the performance characteristics of various turbines
CO4	Explain the working of different components of governing systems, and select the appropriate governing and drive for suitable application
CO5	Compare the working of different electrical power sources
CO6	Prepare maintenance schedule of components of micro hydro plant and carry out fault diagnosis

2. Syllabus

- **INTRODUCTION** **(06 Hours)**

Classification of Hydro-Electric Power Plant, micro hydro power plant overview and components.

- **HYDROLOGY, SITE SURVEY AND CIVIL WORKS** **(10 Hours)**

Introduction, flow prediction, head measurements, site measurements of flow, civil works, system layout, Weir, spillways, channel, penstocks.

- **TURBINES** **(10 Hours)**

Introduction, types: impulse, Pelton, Turgo, Cross flow, Reaction, Francis, Propeller, Kaplan and reverse pump: selection of turbine.

- **GOVERNING AND DRIVE SYSTEM** **(06 Hours)**

Purpose of governing, approaches to the governing, direct couple drives: components.

- **ELECTRICAL POWER** **(06 Hours)**

Basic electricity, choosing the supply, generators, synchronization

- **OPERATION AND MAINTENANCE** **(04 Hours)**

Maintenance of components of micro hydro plant, fault diagnosis.

(Total Lecture Hours: 42)

3. Books Recommended:

1. P. Fraenkel, O. Parish, V. Bolkalders, A. Harvey, Micro-hydro Power: A guide for development workers, ITDG Publishing,1991.

2. L. Kindberg, Micro-Hydro Power: A Beginners Guide to Design and Installation, National Center for Appropriate Technology, 2014.
3. A. Harvey, Micro-Hydro Design Manual: A Guide to Small-Scale Water Power Schemes, Intermediate Technology Publications, 1993.
4. V. Schnitzer, Micro hydro Power scout guide. Hydro Power GTZ, 2009.
5. J.M. Chapallaz, P. Eichenberger, G. Fischer. Manual on pumps used as turbines, Vieweg, 1992.

Micro and Nano-Manufacturing

ME332

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Categorize and describe micro- and nano- manufacturing processes based on given application.
CO2	Explain and select suitable micro machining/ micro forming/ MEMS processes based on given parameters and constraints.
CO3	Distinguish between the requirements for micro and nano manufacturing processes
CO4	Recommend a suitable nano- manufacturing process for a given application
CO5	Propose suitable metrological technique for measuring micro and nano features
CO6	Perform photo lithography, chemical etching and LIGA methods.

2. Syllabus

- **INTRODUCTION** **(02 Hours)**
  Introduction to miniaturization, scaling laws, micro products and design considerations, classification, applications.

- **MICRO MACHINING PROCESSES** **(14 Hours)**
  Principle of mechanical micromachining, micro turning, micro milling, ultrasonic micro machining, abrasive jet micro machining, micro electro discharge machining, micro electro chemical machining, micro grinding, laser micro machining.

- **MICRO FORMING PROCESSES** **(08 Hours)**
  Micro scale plastic deformation, size effect, micro deep drawing, micro extrusion, micro punching, micro blanking, micro fabrication using bulk metallic glasses, flow induced defects.

- **MEMS TECHNIQUES** **(06 Hours)**
  Classification, principle and working, photo lithography, chemical etching, LIGA, materials.

- **INTRODUCTION TO NANO MANUFACTURING** **(08 Hours)**
  Transition from nano technology to nano manufacturing; diamond turn machining; nano joining, nano soldering, nano welding, mechanical bonding, fastening; chemical vapor deposition, scanning tunneling microscopy, nano lithography.

- **MICRO AND NANO METROLOGY** **(04 Hours)**
  Scanning electron Microscopy, optical microscopy, scanning white light interferometry, scanning probe microscopy, computed tomography, digital volumetric imaging, molecular measuring machine.

(Total Lecture Hours: 42)

3. Books Recommended:

1. M. Jackson, Micro and Nano Manufacturing, Springer Science media, 2007.
2. W. Ahmed and M. J. Jackson, Emerging Nano Technologies for Manufacturing, Elsevier, 2nd edition, 2015.
3. I. Fassi and D. Shipley, Micro Manufacturing Technologies and their Applications, Springer, 2017.
4. N. Maluf and K. Williams, Introduction to MEMS Engineering, 2nd edition, Artech house, 2004.
5. K. Gupta, Micro and Precision Manufacturing, Springer, 2018

Finite Element Methods

ME334

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the fundamental concepts of the theory of the finite element method
CO2	Develop element characteristic equation and generation of global equation.
CO3	Determine stress, strain, loads and potential energy for flexure components
CO4	Apply suitable boundary conditions to a global equation for bars, trusses and beams
CO5	Evaluate the governing FE equations for solving 1D and 2D problems
CO6	Apply the FE method for thermal, potential flow and transient problems

2. Syllabus

- **INTRODUCTION** **(07 Hours)**

Basic concepts of FEM, Matrix notations, Exact solution, Approximate solution, general procedure for finite element analysis, various approximate methods, types of elements, Interpolation and shape functions.

- **STIFFNESS (DISPLACEMENT) METHOD** **(07 Hours)**

Introduction to Stiffness matrix, stiffness matrix for spring element, Global stiffness matrix, application of boundary conditions and forces, essential and natural boundary conditions, elimination method, penalty methods, element stresses and strains, Potential Energy approach to derive spring element Equations.

- **TRUSS STRUCTURES** **(07 Hours)**

Stiffness Matrix for Bar Element, Global stiffness matrix for bar elements, computation of stress and strain for bar. Other residual method for one dimensional (1-D) bar problems.

- **FLEXURE ELEMENTS** **(07 Hours)**

Beam theory, Beam stiffness matrix, Global beam stiffness matrix, equivalence load for various distributed loads, potential energy and Galerkin's method for beam elemental equation. .

- **FINITE ELEMENTS FOR TWO-DIMENSIONS** **(06 Hours)**

Introduction to plane stress and plane strain, constant – strain triangle (CST) stiffness matrix, body and surface force for two-dimensional element, finite element solution of plane stress problem.

- **APPLICATIONS OF FEA IN ENGINEERING** **(08 Hours)**

Plane elasticity, Heat conduction, Potential flow, Transient problems and Computer implementation.

(Total Lecture Hours: 42)

3. Books Recommended:

1. R.D. Cook, Concepts and Applications of Finite Element Analysis, 4th Edition, John Wiley & Sons, 2007.
2. D.L. Logan, A first course in the finite element method, 5th Edition, Cenage Learning, 2012.
3. J.N. Reddy, an Introduction to the Finite Element Method, 5th edition, McGraw Hill, x 2017.
4. T.R. Chandrupatla & A.D Belagundu, Finite Elements in Engineering, 4th Edition, Pearson, 2015.
5. O.C. Zienkiewicz, R.L Taylor and J.Z Zhu, The finite element method its basis and fundamentals, 7th edition, Elsevier,2013

Renewable Energy Systems

ME431

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Design solar systems for a given energy utility by applying principles of solar energy conversion
CO2	Estimate the wind potential and perform power forecast analysis
CO3	Design bio-energy based systems for a given utility by applying principles of bio-mass to bio-energy conversion.
CO4	Characterize different types of waste and compare various conversion technologies.
CO5	Compare Hydrogen with other energy resources in present context

2. Syllabus

- **SOLAR RADIATION (12 Hours)**
  Extra-terrestrial and terrestrial, Solar radiation measuring instruments, Estimation of Solar Radiation, Various earth-sun angles. **Solar Energy Conversion Systems:** Solar Thermal Systems: Basics, Flat plate collectors-liquid and air type. Theory of flat plate collectors, selective coating, advanced collectors, Concentrators: optical design of concentrators, solar water heater, solar dryers, solar stills, Solar ponds, solar cooling and refrigeration, Solar thermal power generation. Solar Photovoltaic Systems: Principle of photovoltaic conversion of solar energy, Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Govt. policies. Introduction to Solar Photovoltaic Thermal Systems: Air based, Water based, Refrigerant based Systems. Solar energy storage options: Electrical and Thermal Energy storage options for Solar Energy

- **BIOMASS & BIOENERGY (12 Hours)**
  Biogas System: Anaerobic digestion, biogas production, Types of digesters, installation, operation and maintenance of biogas plants, Biogas plant manure utilisation and manure values, factors affecting biogas production, Biogas utilisation and storage, biogas for motive power generation, design calculations for biogas plants, Govt. policies. **Liquid Biofuels:** Biodiesel – The mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel/Ethanol and other liquid fuels utilization in engine. **Biomass gasification:** Different types, power generation

- **WIND ENERGY CONVERSION SYSTEMS: (08 Hours)**
  History of wind energy, Current status and future prospects, Wind energy in India. Power available in the wind, Components of Wind Energy Conversion Systems, Horizontal and Vertical axis wind turbine, Wind turbine power and torque characteristics, Tip speed ratio, Wind speed prediction and forecasting, Betz limit, Govt. Policies

- **WASTE TO ENERGY CONVERSION (06 Hours)**
  Introducing Municipal Solid Waste Management; Waste Generation and characterization, Waste

Processing Techniques; Source Reduction, Biological Conversion Products: Compost and Biogas, Incineration pyrolysis and Energy Recovery, waste plastic, RDF utilization, Govt. Policies

- **HYDROGEN ENERGY AND FUEL CELLS** **(04 Hours)**

  Benefits of Hydrogen Energy, Hydrogen Production Technologies, Hydrogen Energy Storage, Use of Hydrogen Energy, Advantages and Disadvantages of Hydrogen Energy, Problems Associated with Hydrogen Energy, Basic principle of working of fuel cell.

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. J. A. Duffie and W.A. Beckman, Solar Engineering and Thermal Processes, John Wiley and Sons., 2013.
2. G. N. Tiwari, Solar Energy, Narosa Publishing House Pvt. Ltd., 2012.
3. H. S. Mukunda, Understanding Clean Energy and fuels from biomass. Wiley India Pvt. Ltd, 2011
4. K. M. Mital, Biogas Systems, Principle and Applications. New Age International Ltd, 1996
5. G. D. Rai, Non-Conventional Energy Sources, Khanna Publication, 1988

3. Books Recommended:

1. K. K Autar, Mechanics of Composite Materials, 2nd Edition, CRC Press, 2006.
2. J. N. Reddy, Mechanics of laminated composite plates and shells theory and analysis, 2nd Edition, CRC press, 2003.
3. R. M. Jones, Mechanics of composite materials, 2nd Edition, Taylor and Fransis, 2018.
4. K. Serope, S. Steven, Manufacturing engineering and technology, 8th edition, Pearson, 2019.
5. P. K. Mallick, Fiber-reinforced composites: Materials, Manufacturing, and Design, 3rd Edition, CRC Press, 2007.

Gas Dynamics

ME435

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Predict the effect of compressibility and flow behavior in the field of gas dynamics
CO2	Solve 1-D design problems based on Isentropic, Fanno and Rayleigh flow
CO3	Evaluate the different possible conditions for flow without chocking in 1-D duct with variable area, friction and heat transfer.
CO4	Estimate the position and effect of shock within the 1-D duct.
CO5	Explore the shock phenomenon and learn to use shock polar diagram for 2-D flows.

2. Syllabus

- **INTRODUCTION** **(04 Hours)**
  Thermodynamics of compressible flow, Perfect Gas, General effect of compressibility, Wave Motion, Propagation of Infinitesimal waves, Mach number, Pressure disturbances in a Compressible flow, Stagnation condition.

- **1-DIMENSIONAL, STEADY, ISENTROPIC FLOW IN VARIABLE AREA PASSAGES** **(09 Hours)**
  Introduction, governing equations, Effect of area change in the fluid properties, Equations for Isentropic flow, Maximum mass flow rate, Flow through nozzle & diffuser, Numerical.

- **FLOW IN CONSTANT AREA DUCT WITH FRICTION** **(06 Hours)**
  Introduction, governing equations, Fanno flow equations, Variation of Mach number with duct length, Numerical.

- **FLOW IN CONSTANT AREA DUCT WITH HEAT TRANSFER** **(06 Hours)**
  Introduction, governing equations, Slope of Rayleigh line on p-v diagram, Fundamental equation of Rayleigh line, Maximum heat transfer, Numerical

- **NORMAL SHOCK** **(10 Hours)**
  Introduction, classification of shock, Physical equations of Normal shock, Rankine – Hugoniot Relations, Prandtle equation, Numerical

- **OBLIQUE SHOCK** **(07 Hours)**
  Introduction, governing equations, Rankine–Hugoniot Relations, Prandtle Equations, θ-β-M relation, Shock polar diagram & Hodograph method for the solution of 2- D flows.

(Total Lecture Hours: 42)

3. Books Recommended:

1. S.M. Yahya, Fundamental of Compressible Flow with Aircraft & Rocket Propulsion, New Age International Ltd., 2016
2. E. Rathakrishnan, Gas Dynamics, PHI Learning Pvt. Ltd., 2017
3. A. H. Shapiro, Compressible Fluid Dlow, Ronald Press Company, 1953
4. M. J Zucrow and J.D. Hoffman, Gas Dynamics, John Wiley & Sons, 1976
5. R. D. Zucker and Oscar Biblarz, Fundamental of Gas Dynamics, Wiley, 2002

Fatigue, Fracture and Failure Analysis

ME437

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the principles of fatigue analysis and fracture mechanics
CO2	Explain the S-N curve with respect to mean stress, material surface effect and performance fatigue life analysis
CO3	Describe the behaviour of ductile and brittle failure
CO4	Calculate fracture parameter and analyze crack propagation
CO5	Evaluate stress intensity factor by various methods

2. Syllabus

- **INTRODUCTION AND MECHANISM OF FATIGUE (08 Hours)**
  Fatigue limit, relation between static strength and fatigue strength. Different approaches to fatigue, Stress-life approach (S-N curves), Variable Amplitude Loading, Applications, Environmental effects.

- **THEORY OF ELASTICITY AND PLASTICITY (08 Hours)**
  Notion of stress and strain, Principal Stresses and Principal Coordinates, Maximum shearing Stress, Stress tensors, Compatibility equations, Generalized Hoke's Law, General formulation of elastic problem, Tresca's and von-Mises' Yield Criteria

- **FRACTURE MECHANICS (06 Hours)**
  Introduction to fracture mechanics, fracture modes, Griffith's Fracture Criterion and Irwin's Fracture Criterion, Linear elastic fracture mechanics (LEFM)

- **METHODS FOR EVALUATING STRESS INTENSITY FACTORS (10 Hours)**
  Analytical Solutions- Exact Solutions, Energy approach, Green's function. Semi-Analytical Solutions- Collocations, Conformal mapping. Numerical Methods- Finite element method (FEM), Finite difference method (FDM), Extended finite element method (XFEM). Experimental Methods- Compliance method, Photo elasticity, Interferometry and Holography.

- **INTRODUCTION TO FAILURE (06 Hours)**
  Philosophy and criteria of material selection, Importance of failure analysis and its relationship to material selection, different types of failures, Fundamental causes of failure, General practice in failure analysis, ductile brittle and fatigue failure.

- **CRACK PROPAGATION AND ANALYSIS (04 Hours)**
  The Crack tip Plastic Zone, Methods for Measuring Fracture Toughness, Crack Initiation and Crack Propagation under different loading conditions.

(Total Lecture Hours: 42)

3. Books Recommended:

1. S.P Timoshenko and J.N Goodier , Theory of Elasticity, 3rd Edition, McGraw Hill , 2017.
2. R.B Charlie and A Chaudhary, Failure Analysis of Engineering Materials, McGraw Hill, New York, 2001.
3. K Hellan, Introduction to Fracture Mechanics, McGraw-Hill, 1984.
4. S Mohammadi, Extended finite element method, 1st Edition, Blackwell, 2007.
5. P Kumar, Elements of fracture mechanics, Tata McGraw Hill, New Delhi, 2017.

Robotics

ME438

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the basics of robotic systems.
CO2	Apply the concept of robot arm kinematics.
CO3	Analyse statics and dynamics of robots.
CO4	Analyse manipulator trajectories and robot end effectors.
CO5	Analyse control of robot manipulators.
CO6	Illustrate robot programming, sensing and vision.

2. Syllabus

- **INTRODUCTION** **(03 Hours)**
  Background, Historical development, Robot arm kinematics & dynamics, Manipulator trajectory planning & motion control, Robot sensing, Robot programming language, Machine intelligence.

- **ROBOT ARM KINEMATICS** **(07 Hours)**
  Introduction, The direct kinematics problem, The inverse kinematics problems and their solutions.

- **ROBOT ARM DYNAMICS** **(07 Hours)**
  Introduction, Lagrange-Euler formulation, Newton-Euler formulation, Generalized D'Alembert equations of motion.

- **MANIPULATOR TRAJECTORIES** **(05 Hours)**
  Introduction, General considerations in trajectory planning, Joint interpolated trajectories, Planning of manipulator trajectories.

- **CONTROL OF ROBOT MANIPULATORS** **(06 Hours)**
  Introduction, Control of robot arm, Computed torque technique, Near minimum time control, Variable structure control, Nonlinear decoupled feedback control, Resolved motion control, Adaptive control.

- **ROBOT END EFFECTORS** **(04 Hours)**
  Types of end effectors, Types of grippers, Tools as end effectors, Robot-End effecter Interface, Gripper selection & design.

- **SENSORS IN ROBOTICS** **(04 Hours)**
  Introduction, Transducers & sensors, Sensors in robotics, Range sensing, Proximity sensors, Touch sensors, Tactile sensors, Force & torque sensor, Misc. sensors & sensor based system.

- **ROBOT VISION SYSTEMS** **(04 Hours)**
  Introduction, Low level, medium level and high level vision, Image acquisition, Illumination technique, Imaging geometry, Preprocessing, Relationship between pixels.

- **ROBOT PROGRAMMING LANGUAGES** **(02 Hours)**
  Introduction, Characteristics of robot level languages, Characteristics of task level languages.

(Total Lecture Hours: 42)

---

3. Books Recommended:

1. A. Ghosal, Robotics: Fundamental Concepts and Analysis, 1st Edition, Oxford University Press, 2006.
2. K.S. Fu, R.C. Gonzalez, C.S.G. Lee, Robotics: Control, Sensing, Vision, and Intelligence, 1st Edition, McGraw-Hill, 2008.
3. J. J. Craig, Introduction to Robotics: Mechanics and Control, 4th Edition, Pearson, 2018.
4. S. K. Saha, Introduction to Robotics, 2nd Edition, McGraw-Hill, 2015.
5. N. Odrey, M. Weiss, M. Groover, R. N. Nagel, A. Dutta, Industrial Robotics: Technology, Programming and Applications, 2nd Edition, McGraw-Hill, 2012.

Innovation, Incubation and Entrepreneurship

HU 406

L	T	P	Credit
3	0	0	03

1. Course Outcomes (COs):

At the end of the course the students will be able to:

CO1	Explain the concepts of Entrepreneurship
CO2	Develop skills related to various functional areas of management (Marketing Management, Financial Management, Operations Management, Personnel Management etc.)
CO3	Develop skills related to Project Planning and Business Plan development
CO4	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation
CO5	Build knowledge about Sources of Information and Support for Entrepreneurship
CO6	Develop Entrepreneurial Culture

2. Syllabus:

- **CONCEPTS OF ENTREPRENEURSHIP (10 Hours)**
  Scope of Entrepreneurship, Definitions of Entrepreneurship and Entrepreneur, Characteristics of an Entrepreneur, Entrepreneurial Development models and Theories, Entrepreneurs Vs Managers Classification of Entrepreneurs; Major types of Entrepreneurship – Techno Entrepreneurship, Women Entrepreneurship, Social Entrepreneurship, Intrapreneurship (Corporate entrepreneurship), Rural Entrepreneurship, Family Business etc.; Problems for Small Scale Enterprises and Industrial Sickness; Entrepreneurial Trait Tests; Entrepreneurial Environment – Political, Legal, Technological, Natural, Economic, Socio – Cultural etc. ; Motivation; Business Opportunity Identification

- **FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP (12 Hours)**
  Marketing Management: Basic concepts of Marketing, Development of Marketing Strategy and Marketing plan, Online Marketing, New Product Development Strategy
  Operations Management: Basic concepts of Operations management, Location problem, Development of Operations strategy and plan
  Personnel Management: Main operative functions of a Personnel Manager, Development of H R strategy and plan
  Financial Management: Basics of Financial Management, Ratio Analysis, Capital Budgeting, Working Capital Management, Cash Flow Statement, Break Even Analysis

- **PROJECT PLANNING (06 Hours)**
  Product Development – Stages in Product Development; Feasibility analysis – Technical, Market, Economic, Financial etc.; Project report; Project appraisal; Setting up an Industrial unit – procedure and formalities in setting up an Industrial unit; Business Plan Development

- **PROTECTION OF INNOVATION THROUGH IPR (04 Hours)**
  Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights

- **INNOVATION AND INCUBATION (06 Hours)**

Innovation and Entrepreneurship, Creativity, Green Technology Innovations, Grassroots Innovations, Issues and Challenges in Commercialization of Technology Innovations, Introduction to Technology Business Incubations, Process of Technology Business Incubation

- **SOURCES OF INFORMATION AND SUPPORT FOR ENTREPRENEURSHIP**

  (04 Hours)

  State level Institutions, Central Level institutions and other agencies

(**Total Lecture Hours: 42)**

---

3. Books Recommended:

1. Vasant Desai, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House, India, 6th Revised Edition, 2011
2. P. M. Charantimath, Entrepreneurial Development and Small Business Enterprises, Pearson Education, 3rd Edition, 2018
3. H. David, Entrepreneurship: New Venture Creation, Pearson Education, 2016
4. P. Chandra, Projects: Planning, Analysis, Selection, Financing, Implementation and Review, Tata McGraw Hill, 9th Edition, 2019
5. T. R. Banga & S. C. Shrama, Industrial Organisation & Engineering Economics, Khanna Publishers, 25th Edition, 2015

Further Reading:

1. L. M. Prasad, Principles & Practice Of Management, Sultan Chand & Sons, 8th Edition,2015
2. Everett E. Adam, Ronald J. Ebert, Production and Operations Management , Prentice Hall of India, 5th edition, 2012
3. P. Kotler, K. L. Keller, A. Koshi & M. Jha, Marketing Management – A South Asian Perspective, Pearson, 14th Edition, 2014
4. P. C. Tripathi, Personnel Management & Industrial Relations, Sultan Chand & sons, 21st Edition, 2013
5. P. Chandra, Financial Management, Tata McGraw Hill, 9th Edition, 2015

L	T	P	Credit
3	0	0	03

Mechanics of Composite Materials

ME433

1. Course Outcomes (COs):

At the end of the course, the students will be able to:

CO1	Understating of the composite materials and their constituents.
CO2	Explain the mechanical properties and behaviour of composite materials.
CO3	Apply constitutive equations of composite materials at micro and macro levels.
CO4	Determine stresses and strains relation in composites materials.
CO5	Describe the different types of laminated composites and their failure mechanisms.
CO6	Use the concepts of failure criterias, critically and evaluate the Solve the problems.

2. Syllabus

INTRODUCTION **(04 Hours)**

Introduction of composite materials, Need for composites, Types of composites, Metal matrix, Ceramic matrix and Carbon-Carbon composites, Polymer matrix composites.

COMPOSITE CONSTITUENT MATERIALS **(05 Hours)**

Characteristics of thermosetting and thermoplastic resins. Characteristics of Glass, Carbon and Kevlar Fibers, method of making and properties, types of fiber materials.

MICROMECHANICS OF UNIDIRECTIONAL FIBER COMPOSITES **(10 Hours)**

Prediction of elastic properties using strength of materials approach. Introduction to elasticity based approach for prediction of elastic constants (concentric cylinder model). Empirical relations (Halpin-
Tsai) for elastic property prediction. Comparison of different approaches with examples. Prediction of strength and discussion on failure modes, Prediction of thermal and diffusion properties.

SHORT FIBERCOMPOSITES **(03 Hours)**

Load transfer length, Prediction of elastic properties. Elastic property calculation for random fiber composites

.

ANALYSIS OF ORTHOTROPIC LAMINA **(10 Hours)**

Generalized Hooke's law, Material symmetry. Orthotropic materials and transversely isotropic materials. Transformation of stress and strain. Stress-strain relations for transversely isotropic

lamina under plane stress in material axis and off axis Failure theories (Maximum stress, strain, Tsai-Hill and Tsai-Wu).

ANALYSIS OF LAMINATED COMPOSITES **(10 Hours)**

Description of laminate sequence and type of laminates (UD, Symmetric and Asymmetric, Balanced, Quasi-Isotropic) etc. Classical laminate theory (CLT). Failure analysis of laminates using CLT: First ply failure, progressive failure analysis. Hygro-thermal stresses in laminates. Discussion on interlaminar stresses.

(Total Lecture Hours: 42)

3. Books Recommended:

1. K. K Autar, Mechanics of Composite Materials, 2nd Edition, CRC Press, 2006.
2. J. N. Reddy, Mechanics of laminated composite plates and shells theory and analysis, 2nd Edition, CRC press, 2003.
3. R. M. Jones, Mechanics of composite materials, 2nd Edition, Taylor and Fransis, 2018.
4. K. Serope, S. Steven, Manufacturing engineering and technology, 8th edition, Pearson, 2019.
5. P. K. Mallick, Fiber-reinforced composites: Materials, Manufacturing, and Design, 3rd Edition, CRC Press, 2007.